Population, Pandemics and Planetary Limits

Is Overpopulation the Greatest Threat to Humanity?



Cover photograph: NASA, 'The Blue Marble', Apollo 17, 7 December 1972, photograph AS17-148-22727. Courtesy of NASA Johnson Space Center.

Introduction: The Population Dilemma

The relationship between human population growth and environmental sustainability has long been a subject of scientific, economic and political debate. From Thomas Malthus's eighteenth-century warnings concerning the relationship between population and subsistence to contemporary concerns about climate change, biodiversity loss and resource depletion, the question of whether humanity can continue to expand within the Earth's ecological limits remains unresolved.[1] The world's population exceeded eight billion in 2022, reflecting extraordinary improvements in food production, sanitation, medicine and life expectancy. Yet this demographic achievement has also intensified demands upon land, freshwater, energy and other natural resources, raising questions about the capacity of environmental systems to sustain continued human development.[2]

Population growth, however, cannot be considered independently of the ways societies produce, consume and distribute resources. The environmental consequences of an expanding population depend not only upon the number of people but also upon their levels of consumption, available technologies and systems of economic organisation.[3] A relatively small, affluent population may exert considerably greater environmental pressure than a much larger population with lower per-capita consumption. Consequently, the concept of environmental carrying capacity cannot be understood simply as a fixed numerical limit to human population.

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[1] Thomas Robert Malthus, *An Essay on the Principle of Population*, London, J. Johnson, 1798, pp. 9–10.
[2] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*, New York, United Nations, 2024.
[3] Paul R. Ehrlich and Anne H. Ehrlich, 'Can a Collapse of Global Civilization Be Avoided?', *Proceedings of the Royal Society B: Biological Sciences*, vol. 280, no. 1754, 2013, p. 1.

Rather, it reflects a changing relationship between ecological constraints, technological capabilities and societal choices.

Historical demographic crises provide a useful perspective on this relationship. The Black Death of the fourteenth century, the influenza pandemic of 1918–1919 and the COVID-19 pandemic demonstrate how disease can disrupt population trajectories, economic activity and established social arrangements. Although COVID-19 caused millions of additional deaths, the world's population continued to increase throughout the pandemic, illustrating the distinction between a reduction in population growth and an absolute population decline (see Figure 1).[4] These events also raise a broader historical question: whether demographic shocks fundamentally alter the pressures societies place upon their environments or merely interrupt longer-term patterns of population growth and resource consumption.

[4] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*; William Msemburi et al., ‘The WHO Estimates of Excess Mortality Associated with the COVID-19 Pandemic’, *Nature*, vol. 613, 2023, pp. 130–137.

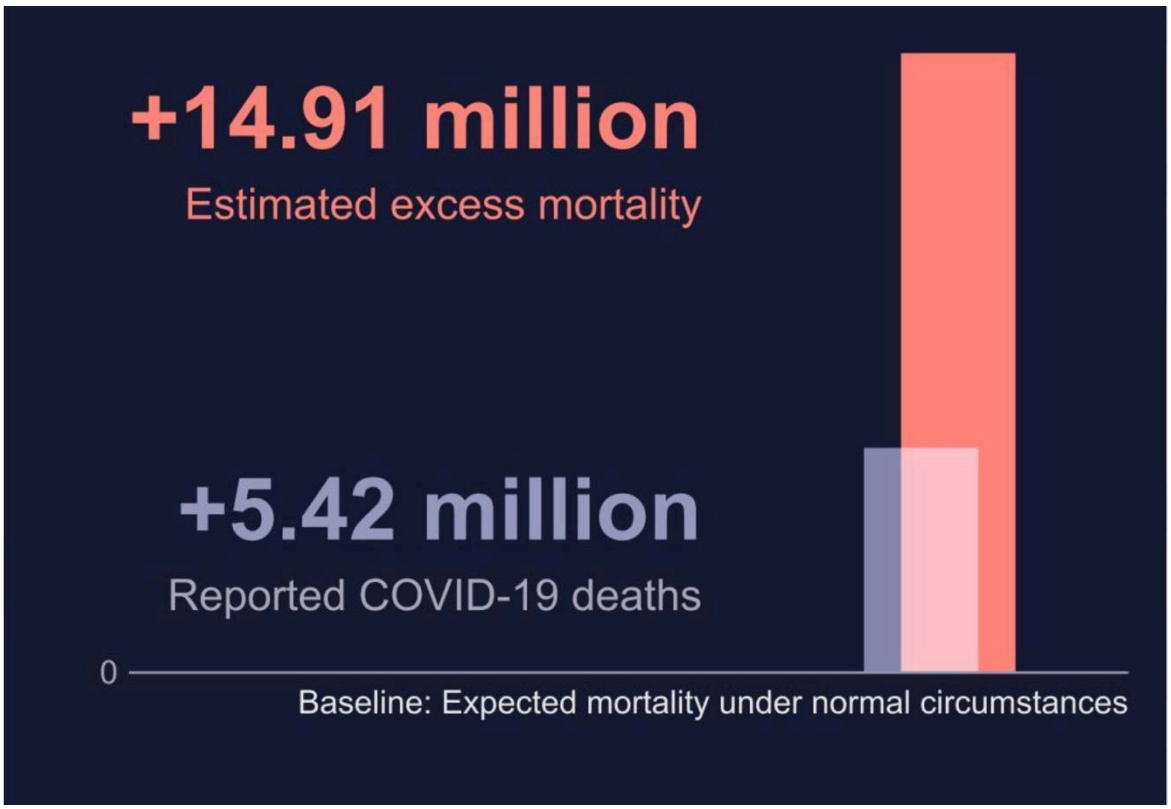

Figure 1. Global excess deaths associated with COVID-19, January 2020–December 20 21. Source: World Health Organization, May 2022 estimates; original WHO illustration.

This essay examines the proposition that uncontrolled population growth represents the principal threat to humanity's environmental future. Drawing upon historical demographic change, the consequences of major pandemics, theories of population pressure and evidence concerning contemporary environmental degradation, it argues that population growth is an important but insufficient explanation of ecological vulnerability. Particular attention is given to the interaction between population, consumption, technological development and political institutions, as well as the historical capacity of societies to adapt to environmental constraints. The discussion concludes by considering practical responses through which humanity might reconcile demographic change, human wellbeing and the maintenance of ecological systems.

The Historical Growth of Human Population

For most of human history, population growth was slow and frequently interrupted by disease, food shortages, warfare and environmental instability. Although the development of agriculture supported larger and more permanent settlements, increases in food production did not necessarily produce sustained improvements in living conditions. High birth rates were commonly offset by high mortality, especially among infants and children. The relationship between population and subsistence was therefore a recurring concern long before Thomas Malthus published his Essay on the Principle of Population in 1798.[5]

Malthus argued that population possessed the potential to increase more rapidly than the food supply, creating recurrent pressures that would ultimately be checked by mortality or restraints on reproduction. His argument reflected the agricultural and economic conditions of his time, but subsequent developments challenged its apparent inevitability. Agricultural innovation, expanded trade, fossil-fuel energy, improved transport and increasingly effective public-health measures allowed societies to support populations far larger than those Malthus had envisaged. Nevertheless, these advances did not abolish ecological constraints; in many instances they changed their character, scale and geographical distribution.[6]

The most dramatic acceleration occurred during the nineteenth and twentieth centuries. The global population reached approximately one billion around 1800, two billion around 1927, four billion in 1974 and eight billion in 2022. These milestones

[5] Thomas Robert Malthus, *An Essay on the Principle of Population*, London, J. Johnson, 1798, chapters 1–2.
[6] Malthus, *An Essay on the Principle of Population*, chapter 2, pp. 13–14.

illustrate the extraordinary scale of demographic expansion, but they should not be mistaken for evidence that the percentage growth rate has increased continuously. In fact, the annual global population growth rate reached its modern peak in the 1960s and has declined substantially since then. The world continues to add people because the existing population is large, even while its proportional rate of increase slows.[7]

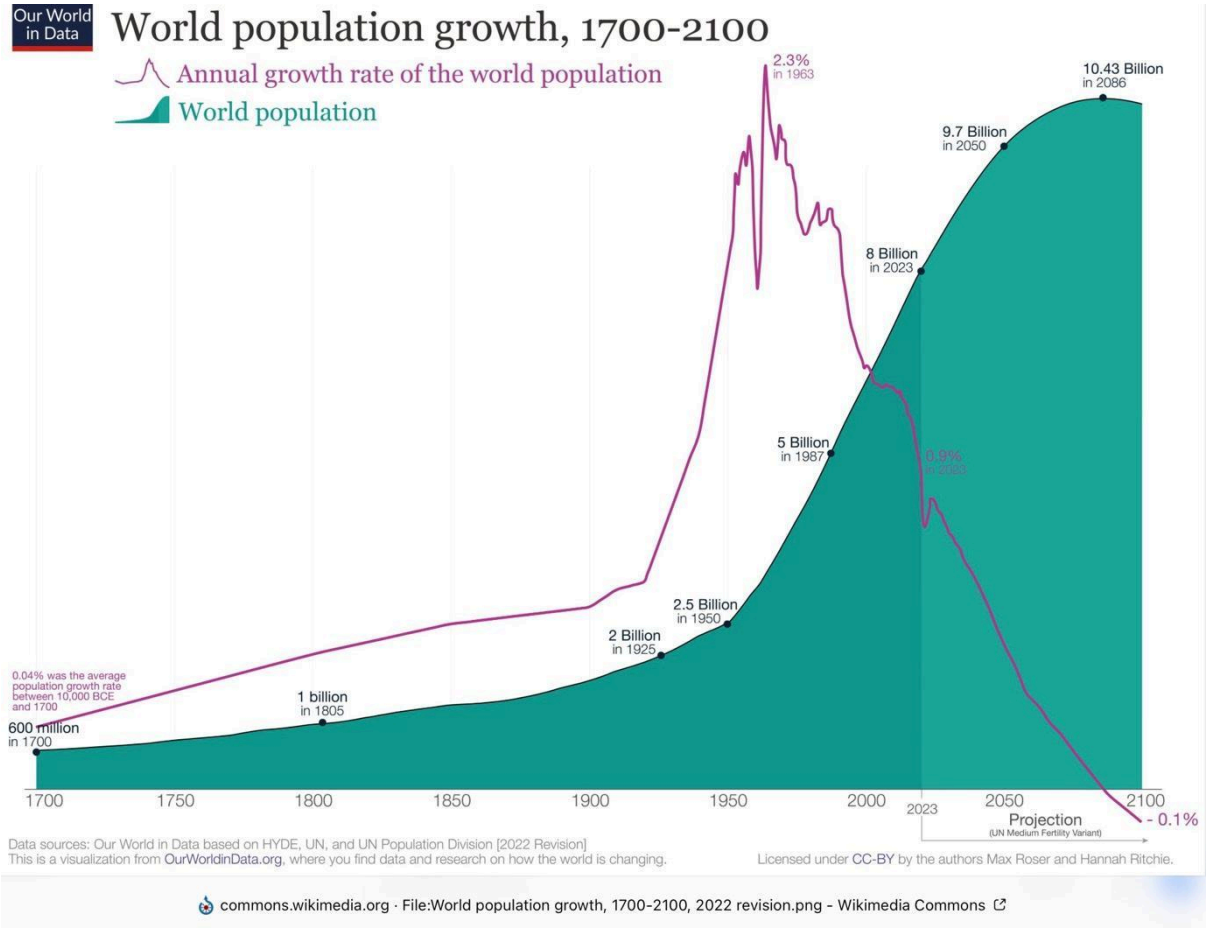

Figure 2. Historical growth of the world population and changes in the annual population growth rate.
Source: Our World in Data, 'World Population Growth', based on historical population estimates and United Nations demographic data.

Demographers describe the underlying historical process through the demographic transition model. In its simplest form, mortality declines first as nutrition, sanitation,

[7] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*; Our World in Data, 'World Population Growth', <https://ourworldindata.org/world-population-growth> [Accessed 27 October 2026].

clean water and medical care improve, while fertility remains relatively high. The resulting gap between births and deaths produces rapid population growth. Later, fertility generally declines in association with changes in economic conditions, urbanisation, education and expectations concerning family size. However, as Philip Kreager observes, demographic transitions have followed markedly different trajectories across societies, with considerable variation in the timing, duration and causes of fertility and mortality decline. Rather than representing a uniform or inevitable progression, demographic change reflects differing social, economic and institutional circumstances. Nevertheless, the demographic transition framework helps explain why periods of rapid population expansion may eventually be followed by slower growth without a corresponding increase in mortality.[8]

Population momentum further complicates the picture. A population with a large proportion of young people may continue growing for decades even after average fertility falls to approximately replacement level, because many individuals are entering their reproductive years. Conversely, populations with sustained low fertility and older age structures may eventually contract. Contemporary demographic patterns therefore combine continued growth in some regions with ageing and declining populations in others. This diversity is obscured when humanity is treated as a single, uniformly expanding population.[9]

The historical record therefore reveals two distinct processes: a dramatic increase in the number of people alive and, since the 1960s, a sustained slowing in the percentage rate of global population growth. Demographic transition and population

[8] Philip Kreager, ‘Two Concepts of Population: The Long View’, paper presented at the XXVI IUSSP International Population Conference, Marrakech, 27 September–2 October 2009, pp. 2–3.
[9] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*, pp. 3–4.

momentum help explain how both developments can occur simultaneously. They also establish a useful context for examining epidemics and pandemics. Disease has repeatedly disrupted population trajectories, sometimes catastrophically, but its wider consequences cannot be understood through mortality figures alone. As Paul and Anne Ehrlich observe, epidemics may interact with resource shortages, economic disruption and weaknesses in social and political organisation, while the effectiveness of institutional responses can influence their consequences. Such interactions demonstrate the importance of distinguishing immediate mortality shocks from their longer-term demographic and societal effects. The following section examines three historical crises to explore these differences.[10]

Pandemics and Population: The Black Death, Influenza and COVID-19

Pandemics provide a useful test of the proposition that population numbers determine the fortunes of societies. Major outbreaks can produce abrupt mortality shocks, disrupt labour and trade, and alter relationships between people and resources. Yet their consequences cannot be read from death totals alone. The scale of mortality relative to the population, its distribution across age groups and regions, and the institutional responses to disease all influence what follows. The Black Death, the influenza pandemic of 1918–1919 and COVID-19 illustrate both the importance and the limits of demographic explanations.[11]

The Black Death reached Europe in the mid-fourteenth century as part of a wider pandemic extending across Eurasia and North Africa. Mortality varied considerably between regions, while its social and economic consequences were shaped by

[10] Paul R. Ehrlich and Anne H. Ehrlich, 'Can a Collapse of Global Civilization Be Avoided?', *Proceedings of the Royal Society B: Biological Sciences*, vol. 280, no. 1754, 2013, article 20122845, pp. 2–4.

[11] Ole J. Benedictow, *The Black Death 1346–1353: The Complete History*, Woodbridge, Boydell Press, 2004, p. 3.

existing institutions, landholding arrangements and the responses of authorities. As John Aberth demonstrates, the demographic catastrophe did not produce uniform economic benefits: although labour shortages created opportunities for some survivors, rising prices, restrictions on wages and differing social arrangements limited their advantages. The experience therefore challenges the assumption that a smaller population necessarily produces a more prosperous or sustainable society.[12]

The scale of the mortality shock is central to understanding its consequences. Estimates remain contested because surviving records are incomplete and regional experiences varied. Aberth reports that mortality during the initial outbreak may have averaged at least 50 per cent across Europe, with substantial differences between localities and the types of records examined.[13] Such losses profoundly altered the relationship between land and labour. Labour shortages encouraged demands for higher wages and changes in agricultural practices, although the economic benefits were unevenly distributed and frequently resisted by established authorities.[14]

Survivors could gain greater bargaining power, although real wages did not rise uniformly or immediately, and authorities frequently attempted to restrict workers' demands. The demographic contraction then changed the distribution and use of resources without ensuring equitable or lasting improvements in living conditions.[15] Demographic contraction could reduce cultivation on marginal land and encourage changes in land use, including the conversion of arable land to pasture and the

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[12] John Aberth, *The Black Death: The Great Mortality of 1348–1350: A Brief History with Documents*, New York, Palgrave Macmillan, 2005, pp. 69–70.
[13] Aberth, *The Black Death*, p. 3.
[14] Aberth, *The Black Death*, pp. 69–70.
[15] Remi Jedwab, Noel D. Johnson and Mark Koyama, 'The Economic Impact of the Black Death', *Journal of Economic Literature*, vol. 60, no. 1, 2022, pp. 142–144.

regrowth of forests in some regions. However, these changes did not remove conflict, inequality or environmental constraints. Their consequences differed between landscapes and agricultural systems, as illustrated by the contrasting experiences of western Europe and irrigation-dependent Egypt. Moreover, the Black Death was not a deliberate correction to population pressure; it was a human catastrophe whose consequences depended on the circumstances of survivors. Using it as evidence that mass mortality provides an environmental solution would confuse an observed historical effect with an ethically defensible policy.[16]

The influenza pandemic of 1918–1919 unfolded amid the movement of military personnel, wartime disruption and increasingly interconnected transport networks. Its demographic effects differed from those of the Black Death not only in scale but also in the age distribution of mortality: deaths were unusually concentrated among young adults, alongside other vulnerable groups. Reliable global totals remain elusive because death registration was incomplete in many regions and wartime conditions complicated reporting. Johnson and Mueller estimated that approximately 50 million people died worldwide, while acknowledging that the total might have approached 100 million. Even the lower estimate represented a devastating loss, but, unlike the demographic collapse experienced in much of fourteenth-century Europe, the influenza pandemic did not initiate a sustained contraction of the world population. Its consequences were shaped by the interaction of disease, war, public-health capacity and social conditions rather than mortality alone.[17]

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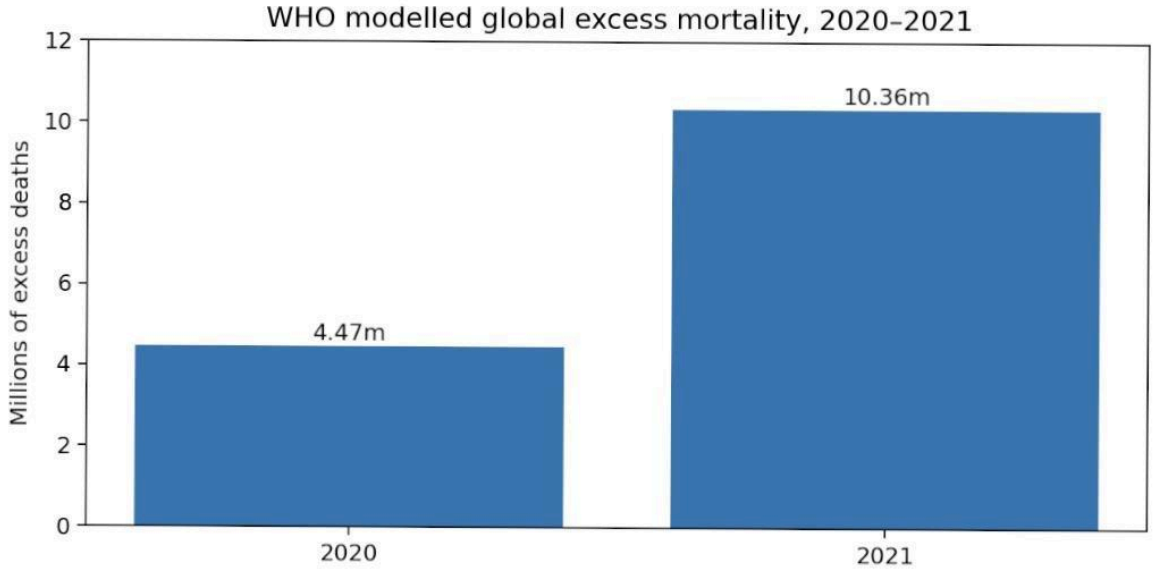
[16] Jedwab, Johnson and Koyama, ‘The Economic Impact of the Black Death’, pp. 156–157.
[17] Niall P. A. S. Johnson and Juergen Mueller, ‘Updating the Accounts: Global Mortality of the 1918–1920 “Spanish” Influenza Pandemic’, *Bulletin of the History of Medicine*, vol. 76, no. 1, 2002, p. 105.

COVID-19 provides a recent comparison for which demographic evidence is more extensive, although estimates remain uncertain. For 2020–2021, the World Health Organization estimated approximately 14.9 million excess deaths associated directly or indirectly with the pandemic (uncertainty interval 13.3–16.6 million). The underlying peer-reviewed analysis estimated 14.83 million excess deaths, compared with 5.42 million deaths officially reported to WHO as due to COVID-19 over the same period. Excess mortality captures departures from expected all-cause deaths and therefore helps address variations in testing and death certification. It is nevertheless a model-based estimate rather than an exact count. Despite the severe mortality shock, the global population continued to increase because births worldwide exceeded deaths. The pandemic reduced population relative to a plausible no-pandemic trajectory but did not cause an absolute worldwide population decline.[18]

The size of that counterfactual difference cannot be inferred from excess deaths alone. Changes in fertility, deaths brought forward from later years, and the effects of the pandemic after 2021 also influence the population that would otherwise have been alive. Figure 3 therefore presents the better-supported global excess-mortality estimates for 2020 and 2021, rather than claiming to reconstruct an unverified no-COVID population series for 2015–2023. A population counterfactual would require an explicitly specified demographic model incorporating births, deaths and age structure. The historical lesson is consequently precise but limited: a major

[18] William Msemburi et al., ‘The WHO Estimates of Excess Mortality Associated with the COVID-19 Pandemic’, *Nature*, vol. 613, 2023, pp. 130–137; World Health Organization, ‘14.9 Million Excess Deaths Associated with the COVID-19 Pandemic in 2020 and 2021’, 5 May 2022, <https://www.who.int/news/item/05-05-2022-14.9-million-excess-deaths-were-associated-with-the-covid-19-pandemic-in-2020-and-2021> [Accessed 28 October 2026].

mortality crisis can slow demographic expansion without reversing it, while its wider consequences depend on the institutions and conditions in which it occurs.[19]



Source: Msemburi et al. (2023), estimates of 4.47 million in 2020 and 10.36 million in 2021. These are excess deaths, not population shortfalls. The 2020–2021 total differs slightly from the WHO press-release rounding of 14.9 million.

Figure 3. WHO modelled global excess mortality, 2020–2021.
Source: Data from William Msemburi et al., 'The WHO Estimates of Excess Mortality Associated with the COVID-19 Pandemic', Nature, 613 (2023), 130–137. Graph prepare d from the published estimates.

The three pandemics therefore caution against treating population as a single independent cause of social or environmental change. The Black Death transformed labour relations in some settings, influenza revealed the vulnerability of interconnected societies, and COVID-19 demonstrated that an immense mortality shock could coexist with continued global population growth. In each case, outcomes depended on institutions, inequality, knowledge and responses to crisis. The central

[19] William Msemburi et al., 'The WHO Estimates of Excess Mortality Associated with the COVID-19 Pandemic', *Nature*, 613 (2023), 130–137, https://doi.org/10.1038/s41586-022-05522-2; World Health Organization, '14.9 Million Excess Deaths Associated with the COVID-19 Pandemic in 2020 and 2021', 5 May 2022, https://www.who.int/news/item/05-05-2022-14.9-million-excess-deaths-were-associated-with-the-covid-19-pandemic-in-2020-and-2021.

question for environmental sustainability is consequently not merely how many people live on Earth, but how societies organise their demands on resources and protect human wellbeing under changing conditions.

Population, Consumption and Environmental Degradation

Population growth is an important driver of environmental change, but its consequences cannot be assessed by counting people alone. A larger population generally requires more food, housing, energy, water and infrastructure, although the magnitude of those demands depends on how goods are produced and distributed. The central analytical question is therefore not whether population matters, but how it interacts with consumption, technology and political choices. This distinction is essential when evaluating the proposition that overpopulation is the overriding cause of contemporary environmental deterioration.[20]

A useful starting point is the IPAT framework, developed through debates involving Paul Ehrlich and John Holdren. It expresses environmental impact (I) as the product of population (P), affluence or consumption per person (A), and the environmental impact of the technologies used to meet that consumption (T). The framework is a conceptual identity rather than a predictive law: its terms must be defined carefully, and interactions between them are often complex. Nevertheless, it demonstrates why the same number of people can generate markedly different environmental outcomes. Population expansion can increase total impact even when consumption

[20] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*, New York, United Nations, 2024.

per person remains unchanged, while higher consumption can increase impact without any population growth.[21]

Climate change offers a particularly clear illustration. The Intergovernmental Panel on Climate Change identifies population growth and rising economic activity as important underlying drivers of emissions, but emissions are distributed very unevenly across regions, income groups and households. Wealthier populations generally consume more energy and material goods, while the carbon intensity of electricity, transport, industry and agriculture varies greatly. A person living within a fossil-fuel-intensive economy may therefore contribute much more to greenhouse gas emissions than someone whose material consumption is limited. Reducing emissions requires attention to energy systems and consumption patterns as well as demographic change.[22]

Differences in consumption are particularly important when interpreting global emissions. The environmental consequences of population growth are not evenly distributed across humanity: higher-income households generally account for a disproportionate share of consumption-based greenhouse gas emissions, while poorer households often contribute relatively little yet remain highly exposed to climatic disruption. Consumption-based accounting is useful here because it attributes emissions to the final consumers of goods and services, including emissions generated elsewhere during production. This does not make population

[21] Paul R. Ehrlich and John P. Holdren, 'Impact of Population Growth', *Science*, vol. 171, no. 3977, 1971, pp. 1212–1217.
[22] Intergovernmental Panel on Climate Change, *Climate Change 2022: Mitigation of Climate Change*, Working Group III Contribution to the Sixth Assessment Report, Cambridge, Cambridge University Press, 2022, Summary for Policymakers.

irrelevant; additional people still require resources and infrastructure. It does, however, challenge the assumption that each additional person imposes an equivalent environmental burden. Policies concerned solely with reducing population growth may consequently overlook substantial opportunities to reduce emissions through changes in energy supply, transport, housing and high-consumption lifestyles.[23]

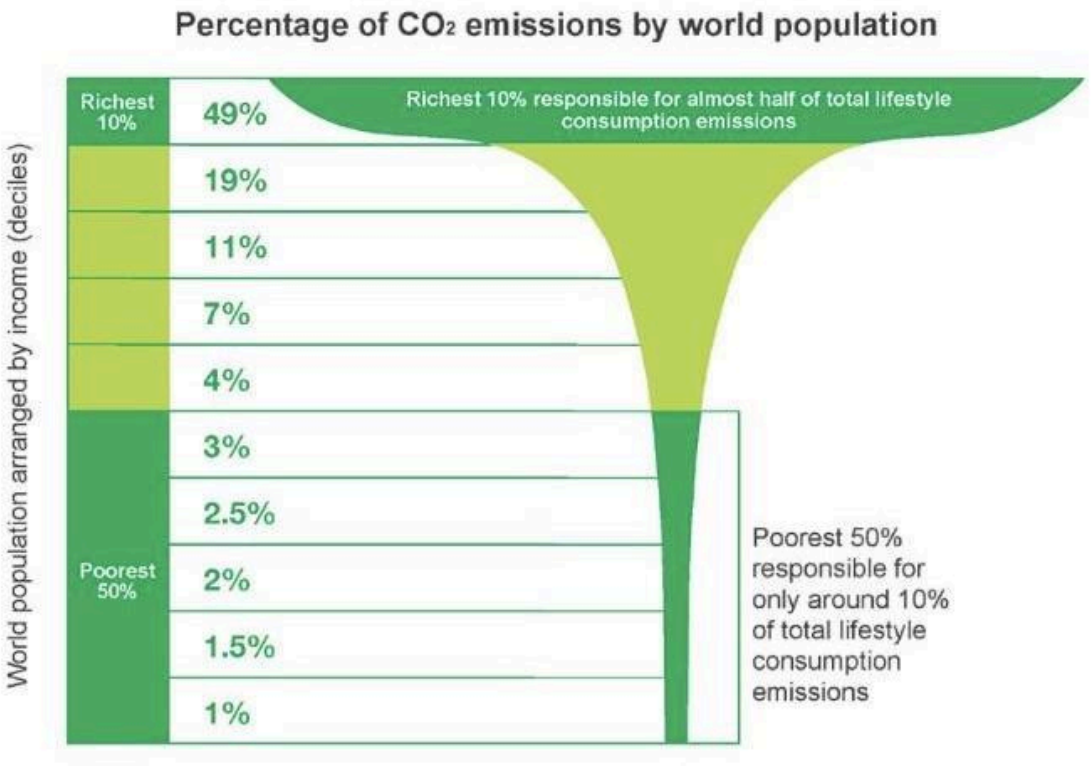


Figure 4. Global income inequality and associated lifestyle consumption CO_2 emissions.
Source: Reproduced from Oxfam, Extreme Carbon Inequality: Why the Paris Climate Deal Must Put the Poorest, Lowest Emitting and Most Vulnerable People First (2015), Figure 1.[24]

The same reasoning applies to land use and biodiversity. Expanding agriculture, settlements, transport networks and extractive industries can fragment habitats and reduce ecological resilience. Yet land conversion is influenced not only by the

[23] Intergovernmental Panel on Climate Change, *Climate Change 2022: Mitigation of Climate Change*, Summary for Policymakers, discussion of household emissions and consumption inequality.
[24] Oxfam, *Extreme Carbon Inequality: Why the Paris Climate Deal Must Put the Poorest, Lowest Emitting and Most Vulnerable People First*, Oxfam Media Briefing, 2 December 2015, Figure 1.

number of mouths to feed but also by diets, food losses, international trade, farming practices and demand for commodities. The global assessment undertaken by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services identifies changes in land and sea use among the leading direct drivers of biodiversity loss. Population growth may intensify these pressures, but it does not fully explain why some landscapes are protected while others are transformed.[25]

Freshwater and food security likewise reveal the limitations of a purely numerical explanation. More people increase aggregate demand, particularly where water supplies and agricultural land are already under stress. However, scarcity can also arise from inefficient irrigation, pollution, unequal access, poor governance and climatic variability. A society may produce sufficient food in aggregate while sections of its population remain undernourished because they lack the income, infrastructure or political influence needed to obtain it. Population pressure is thus one element of vulnerability, not a substitute for examining the institutions through which resources are allocated.[26]

Technological change further complicates any simple relationship between population and environmental decline. Improvements in crop yields, water efficiency, renewable electricity and material recycling can reduce environmental impact per unit of output. Such gains are not automatic solutions: greater efficiency can sometimes encourage additional consumption, while new technologies require land,

[25] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, *Global Assessment Report on Biodiversity and Ecosystem Services*, Bonn, IPBES Secretariat, 2019, Summary for Policymakers.
[26] Food and Agriculture Organization of the United Nations, *The State of Food Security and Nutrition in the World 2024*, Rome, FAO, 2024; UN-Water, *United Nations World Water Development Report 2024*, Paris, UNESCO, 2024.

minerals and energy of their own. Nor can innovation indefinitely remove every ecological constraint. The relevant question is whether technological and institutional changes can reduce total environmental pressures quickly enough to offset the effects of population and consumption growth.[27]

These considerations neither dismiss nor minimise population concerns. Where rapid growth outpaces investment in sanitation, housing, education and health services, substantial human and environmental difficulties can follow.
Alon Tal, for example, argues that population growth remains a fundamental driver of environmental degradation, while acknowledging the substantial contribution of consumption, particularly in affluent societies.[28] Yet attributing planetary degradation primarily to the number of people risks obscuring the disproportionate influence of high−consumption lifestyles and the decisions governing energy, agriculture and land use. A more persuasive historical and environmental interpretation treats population as a significant multiplier of pressure, whose consequences are shaped by affluence, technology, inequality and governance. This broader perspective provides a stronger basis for assessing both societal vulnerability and practical responses.[29]

Population Pressure, Environmental Stress and Societal Collapse

Historical accounts of societal collapse have frequently linked population pressure to environmental deterioration. When expanding populations require greater agricultural output, fuel, water and settlement space, the resulting demands may exceed the

[27] Intergovernmental Panel on Climate Change, *Climate Change 2022: Mitigation of Climate Change*, chapters on demand, efficiency and mitigation pathways.
[28] Alon Tal, 'The Environmental Impacts of Overpopulation', *Encyclopedia*, vol. 5, no. 2, 2025, article 45, pp. 21-22.
[29] Thomas Wiedmann, Manfred Lenzen, Lorenz T. Keyßer and Julia K. Steinberger, 'Scientists' Warning on Affluence', *Nature Communications*, vol. 11, no. 1, 2020, article 3107, p. 5.

capacity of landscapes or institutions. Yet the historical record does not establish a simple progression from population increase to resource exhaustion and collapse. Societies confronted with similar environmental pressures have responded in different ways, depending on political organisation, economic arrangements, available technologies and the distribution of resources.[30]

The contrast between Thomas Malthus and Ester Boserup illustrates why population pressure should not be treated as a predetermined route to collapse. Malthus emphasised the danger that population might grow faster than the means of subsistence, whereas Boserup argued that rising population density could encourage more intensive cultivation, altered labour practices and agricultural innovation.[31] Her interpretation does not imply that intensification is environmentally benign: greater output may depend upon additional labour, irrigation or changes in land use, with consequences for soils, water and ecosystems. Taken together, these perspectives suggest that demographic pressure creates challenges to which societies may respond through innovation, redistribution, expansion or intensified exploitation, rather than through one inevitable historical sequence.[32]

Ancient Mesopotamia provides an instructive example. Irrigated agriculture supported substantial settlements and complex political institutions, but cultivation in parts of southern Mesopotamia also confronted salinisation, changing watercourses and difficulties in maintaining irrigation works.[33] Environmental pressures interacted

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[30] Malthus, *An Essay on the Principle of Population*, chapters 1–2.
[31] Ester Boserup, *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*, London, George Allen & Unwin, 1965, pp. 4, 16–18.
[32] Boserup, *The Conditions of Agricultural Growth*, pp. 13–14.
[33] Robert McC. Adams, *Heartland of Cities: Surveys of Ancient Settlement and Land Use on the Central Floodplain of the Euphrates*, Chicago, University of Chicago Press, 1981, pp. 19–21.

with political instability, administrative arrangements and the fiscal demands of ruling authorities.[34] It would be misleading, however, to interpret the changing fortunes of Mesopotamian states as the inevitable consequence of excessive population alone. As Adams demonstrates, ecological conditions, settlement patterns and political trajectories varied considerably across time and place.[35]

The Classic Maya case similarly cautions against single-cause explanations. Archaeological and palaeoclimatic research has identified episodes of severe drought associated with political disruption and demographic contraction in parts of the Maya lowlands.[36] High population densities, agricultural intensification and environmental degradation may have increased vulnerability to declining rainfall, while warfare, competition among rulers and shifting political alliances further influenced events.[37] The consequences were neither immediate nor geographically uniform. Some political centres declined or were abandoned, while populations migrated, reorganised or persisted elsewhere.[38] What is commonly described as the 'Maya collapse' therefore represented a prolonged and uneven transformation of political institutions and settlement patterns rather than the extinction of Maya society.

The Late Bronze Age eastern Mediterranean offers a further comparison. Around the end of the thirteenth and beginning of the twelfth centuries BCE, several palace-centred political systems experienced destruction, fragmentation or

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[34] Adams, *Heartland of Cities*, pp. 213–214.
[35] Adams, *Heartland of Cities*, pp. 250–252.
[36] Douglas J. Kennett et al., 'Development and Disintegration of Maya Political Systems in Response to Climate Change', *Science*, vol. 338, no. 6108, 2012, pp. 788, 791.
[37] Kennett et al., 'Development and Disintegration of Maya Political Systems', pp. 789–791.
[38] Kennett et al., 'Development and Disintegration of Maya Political Systems', p. 791.

substantial reorganisation. Proposed explanations include prolonged drought, warfare, disrupted trade, migration and political instability.[39] The evidence remains contested, and population pressure cannot be isolated as a dominant cause. Rather than demonstrating a single pathway to collapse, the episode illustrates how interconnected political and economic systems could become vulnerable when several disturbances occurred together, potentially reinforcing one another and extending their consequences across the wider region.[40]

Joseph Tainter's analysis of complex societies provides a broader interpretative framework. As Neema Parvini explains, Tainter regarded societies as problem-solving organisations in which increasing complexity initially offers practical advantages but eventually may produce diminishing returns on investment in administration, defence, information processing and other institutions. Such arrangements can become increasingly expensive to maintain, leaving societies vulnerable when additional environmental, economic or political pressures arise. Parvini nevertheless questions the limitations of Tainter's predominantly economic explanation, particularly its insufficient attention to cultural influences and the difficulties associated with identifying a single underlying cause of collapse.[41] James C. Scott similarly draws attention to the concentration of people, crops and authority in early states, where disease, coercion and dependence on taxable staple production could create distinctive risks. Neither approach establishes population numbers as an adequate explanation in isolation.[42]

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[39] Eric H. Cline, *1177 B.C.: The Year Civilization Collapsed*, revised and updated edn, Princeton, Princeton University Press, 2021, pp. 134–139.
[40] Cline, *1177 B.C.*, pp. 165–166, 172–173.
[41] Neema Parvini, *The Prophets of Doom*, Exeter, Imprint Academic, 2023, pp. 165–167, 178–180.
[42] James C. Scott, *Against the Grain: A Deep History of the Earliest States*, New Haven, Yale University Press, 2017, pp. 116–121, 150–153.

These comparisons also require care in the use of the term ‘collapse’. The failure of a state or administrative system need not entail the disappearance of its population, culture or accumulated knowledge. Middleton’s discussion reinforces the distinction between the breakdown of complex political organisation and the complete disappearance of a society.[43] Mesopotamian irrigation, Maya regional diversity and the disruption of eastern Mediterranean palace economies point to different combinations of environmental stress and institutional vulnerability; none provides a straightforward demonstration that population growth alone caused political breakdown. In some circumstances fragmentation opened possibilities for adaptation, while in others it intensified deprivation and violence. The historical question is therefore not whether population pressure is harmless, but when societies possess the resources, knowledge and institutions to respond without transferring costs to vulnerable people or ecosystems. That question also informs the demographic choices facing the contemporary world.[44]

The Demographic Future: Growth, Stabilisation or Decline?

The prospect of an ever-expanding human population is central to arguments that humanity is approaching unavoidable environmental limits. Yet contemporary demographic evidence suggests a more complicated future. According to the United Nations’ World Population Prospects 2024, the global population, estimated at 8.2 billion in 2024, is projected to reach approximately 10.3 billion in the mid-2080s before declining slightly to about 10.2 billion by 2100. The United Nations estimates an 80 per cent probability that world population will peak during this century. These

[43] Guy D. Middleton, ‘Introducing Collapse’, in Guy D. Middleton (ed.), *Collapse and Transformation: The Late Bronze Age to Early Iron Age in the Aegean*, Oxford, Oxbow Books, 2020, pp. 1–2.
Iron Age in the Aegean, ed. by Guy D. Middleton (Oxford: Oxbow Books, 2020), pp. 1–2.
[44] Middleton, ‘Introducing Collapse’, pp. 5–6.

are projections contingent upon assumptions about future fertility and mortality, rather than predictions of an inevitable outcome.[45]

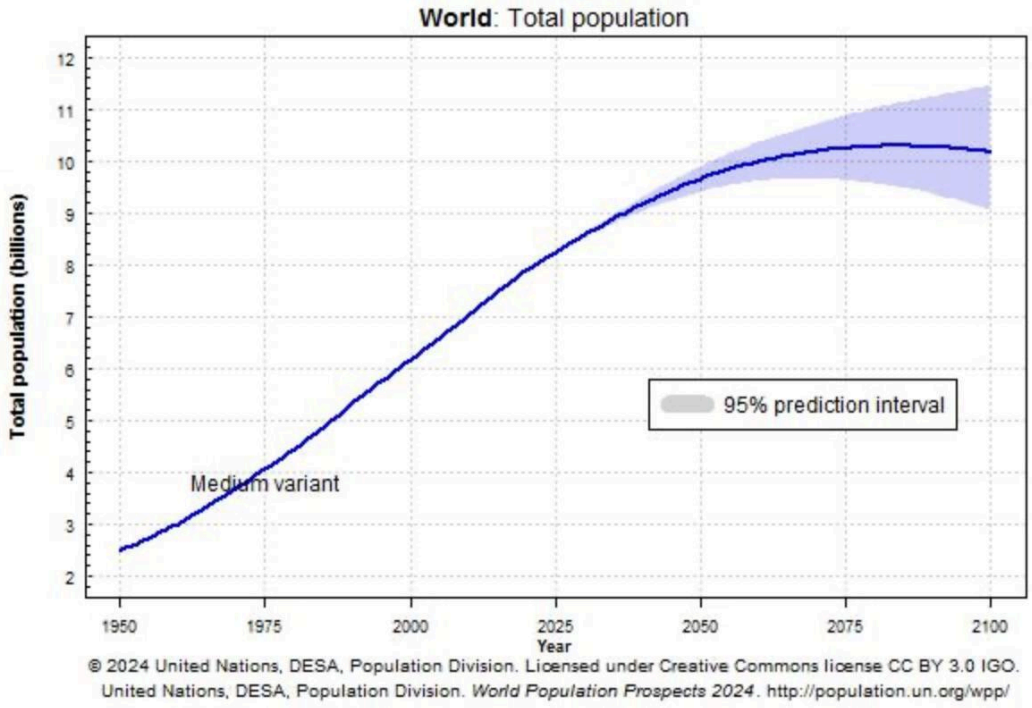

Figure 5. Projected world population growth and stabilisation, 1950–2100. Source: United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2024 (2024).

The most important influence upon this changing trajectory is declining fertility. The global average fell from approximately 3.3 births per woman in 1990 to 2.3 in 2024, while more than half of all countries and areas now record fertility below about 2.1 births per woman, the conventional long-term replacement benchmark in low-mortality populations. Improvements in child survival, urbanisation, expanded education and changing opportunities for women have accompanied this transition, although their relative importance varies between societies. Population momentum nevertheless means that numbers may continue rising for decades where large

[45] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*, New York, United Nations, 2024, key messages and chapter 1.

generations of young people enter their reproductive years, even after fertility declines substantially.[46]

These changes are far from uniform. By 2024, populations had already peaked in 63 countries and areas, including China, Germany and Japan, while other countries, particularly in parts of sub-Saharan Africa, are expected to experience substantial growth. Rapid growth may place additional demands upon schools, housing, healthcare, employment and food systems, especially where public infrastructure is already inadequate. Conversely, sustained low fertility and longer life expectancy can produce ageing populations, smaller workforces and increased pressure upon pensions and care services. Thus, population growth and population decline may present different but equally serious questions of governance and social provision.[47]

International migration further complicates national demographic futures. Movement across borders may offset population decline and labour shortages in receiving countries, while affecting the age structure and skills available in countries of origin. Migration, however, does not increase the world's total population; it redistributes people and therefore the geographical distribution of resource demand. The United Nations anticipates that immigration will become a principal source of population growth in several countries, including Australia. Demographic outcomes consequently reflect not only births and deaths but also policy, opportunity and the uneven geography of economic development.[48]

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[46] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*, key messages on fertility.
[47] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*, key messages on countries whose populations have peaked and those still growing.
[48] United Nations, 'Population', *Global Issues*, <https://www.un.org/en/global-issues/population> [Accessed 28 October 2026].

The environmental implications of these projections require careful interpretation. A slowing rate of population growth may eventually moderate the expansion of aggregate demand, but it does not automatically reduce greenhouse gas emissions, habitat destruction or material consumption. An additional person living within a resource-intensive economy may have a markedly different environmental impact from someone whose consumption remains low. Equally, a stable or shrinking population can continue to damage ecosystems if production systems remain wasteful or dependent upon fossil fuels. The significance of demographic change therefore lies in its interaction with the patterns of consumption and technological choices discussed earlier, rather than in population totals alone.[49]

For the argument advanced in this essay, the projected population peak is an important qualification to claims of indefinitely accelerating human numbers. It does not imply that environmental pressures will disappear, nor that all regions will follow the same demographic path. Instead, it shifts attention towards the choices societies make as their populations grow, age or contract. Whether the coming century is characterised by worsening ecological vulnerability or greater sustainability will depend as much upon political institutions, resource distribution and the environmental intensity of economic activity as upon demographic change itself.

The prospect of global population stabilisation does not, however, guarantee environmental sustainability. Even if fertility continues to decline and the world's

[49] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*, discussion of sustainability; compare Ehrlich and Holdren, ‘Impact of Population Growth’.

population eventually contracts, the environmental consequences of human activity will remain dependent upon patterns of consumption, energy production, technological development and political decision-making. Moreover, demographic transitions will occur unevenly, with some societies confronting rapid population growth while others face ageing populations and declining workforces. These contrasting circumstances suggest that population policy cannot provide a universal solution to environmental pressures. The central challenge is therefore not simply to limit the number of people inhabiting the planet, but to develop economic and political arrangements capable of supporting human wellbeing within ecological limits.

What Can Humanity Do? Practical Pathways Towards Sustainability

Recognising population growth as one contributor to environmental pressure does not imply that population reduction is either a sufficient remedy or an appropriate immediate policy objective. The historical evidence considered in this essay points instead towards several interacting priorities: enabling voluntary demographic transitions, reducing environmental damage associated with production and consumption, and strengthening societies' capacity to withstand ecological and economic disruption. These responses operate on different timescales. Changes in energy systems or land management can reduce impacts within years, whereas demographic changes generally unfold across generations.[50]

The first priority is to support reproductive autonomy rather than impose numerical population targets. Access to voluntary family planning, contraception and

[50] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*, New York, United Nations, 2024.

reproductive healthcare allows individuals to make informed decisions about family size. Education, particularly for girls, and expanded opportunities for women are also associated with later childbearing and lower fertility in many settings, although the relationships differ across societies. Reductions in child mortality and greater economic security can further alter incentives for large families. Such measures can contribute to slower population growth while advancing human wellbeing independently of their demographic consequences. Coercive population policies, by contrast, raise serious ethical objections and can produce lasting social harm.[51]

Demographic change alone, however, cannot address the immediate environmental effects of existing populations. The IPAT framework reminds us that the consequences of human activity depend upon consumption and technology as well as numbers. Rapid reductions in greenhouse gas emissions therefore require changes in energy generation, transport, buildings and industrial production, especially where consumption and emissions per person are high. Greater energy efficiency, electrification and the expansion of low-emissions electricity can reduce environmental impact without requiring a decline in population. The pace and effectiveness of these transitions depend on investment, infrastructure and political choices rather than demographic trends alone.[52]

Food production and land use provide a second area for practical intervention. Agriculture supports human survival but can also contribute to deforestation,

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[51] United Nations Population Fund, *State of World Population 2023: 8 Billion Lives, Infinite Possibilities*, New York, UNFPA, 2023; United Nations Educational, Scientific and Cultural Organization, *Global Education Monitoring Report 2020*, Paris, UNESCO, 2020.

[52] Intergovernmental Panel on Climate Change, *Climate Change 2022: Mitigation of Climate Change*, Cambridge, Cambridge University Press, 2022.

freshwater depletion, soil degradation and biodiversity loss. Improvements in soil and water management, protection of remaining natural habitats, more efficient supply chains and reductions in food loss and waste can lessen these pressures. Yet technological efficiency should not be treated as an automatic environmental gain: increased production may encourage further expansion unless accompanied by appropriate regulation and land-use planning. Conservation therefore requires decisions about which landscapes and ecosystems should be protected, restored or used, and under what conditions.[53]

The unequal distribution of environmental impacts complicates the proposition that population size is the overriding problem. A person living in a high-consuming economy may contribute far more to emissions and material demand than someone in a low-income society. Equally, those who have contributed least to environmental change may face severe consequences from drought, flooding, food insecurity or extreme heat. Policies that concentrate only on fertility in poorer countries risk overlooking the consumption and production systems responsible for much existing damage. Fairness is not merely a moral consideration: measures perceived as unjust may prove politically difficult to sustain.[54]

Historical experiences of environmental stress also suggest the importance of resilience. Societies need reliable public-health systems, diversified food and water supplies, early-warning arrangements, and institutions capable of responding to

[53] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, *Global Assessment Report on Biodiversity and Ecosystem Services*, Bonn, IPBES Secretariat, 2019; Food and Agriculture Organization of the United Nations, *The State of Food and Agriculture 2019: Moving Forward on Food Loss and Waste Reduction*, Rome, FAO, 2019.
[54] Intergovernmental Panel on Climate Change, *Climate Change 2023: Synthesis Report*, Geneva, IPCC, 2023.

uncertainty. Urban planning can reduce exposure to heat and flooding; ecological restoration can protect watersheds and coastlines; and social protection can help households adapt when livelihoods are disrupted. These interventions do not eliminate environmental hazards, but they can prevent shocks from developing into wider humanitarian crises. Their success depends upon local conditions and institutional capacity, rather than the existence of a universal formula.[55]

Finally, the demographic future itself requires differentiated responses. Some countries face rapid population growth and pressure on schools, housing and employment; others confront ageing, shrinking workforces and the challenge of maintaining services. Neither circumstance is necessarily evidence of failure. Governments can respond through education, healthcare, infrastructure, employment policy and, where appropriate, migration, while respecting individual rights. The United Nations' projections indicate that global population growth is likely to slow substantially during this century, but they do not remove the need to reduce environmental impacts now.[56] These contrasting circumstances reinforce the need to distinguish between environmental measures capable of producing immediate benefits and voluntary demographic changes whose effects may emerge over several generations.

The practical conclusion is therefore not that population is irrelevant, but that it is only one part of a broader historical and environmental problem. A credible response

[55] United Nations Office for Disaster Risk Reduction, *Global Assessment Report on Disaster Risk Reduction 2022: Our World at Risk*, Geneva, UNDRR, 2022; Intergovernmental Panel on Climate Change, *Climate Change 2022: Impacts, Adaptation and Vulnerability*, Cambridge, Cambridge University Press, 2022.

[56] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*.

must combine voluntary improvements in reproductive choice with reductions in resource-intensive consumption, technological change, ecosystem protection and effective governance. Such a programme offers no single solution and will involve difficult trade-offs. Nevertheless, it addresses the mechanisms through which human numbers become environmental pressures, rather than treating the existence of people itself as the principal problem.[57]

Conclusion: Beyond Population Numbers

Human population growth has undoubtedly intensified demands upon land, water, energy and biological resources. The concern that an expanding population may exceed the capacity of environmental systems is therefore neither trivial nor misplaced. Yet the historical and demographic evidence examined here suggests that population size cannot, by itself, explain the scale or distribution of environmental damage. It would therefore be misleading to identify overpopulation as humanity's single greatest threat, since the severity of environmental pressures depends not only upon the number of people but also upon the ways in which they live and the institutions governing their activities. The consequences of population growth depend upon how societies organise production, consume resources, deploy technology and distribute both opportunities and risks.

The Black Death, the influenza pandemic of 1918–1919 and COVID-19 demonstrate that severe mortality crises can profoundly disrupt societies, but they provide little justification for treating catastrophic population loss as a solution to environmental pressures. Despite substantial excess mortality during COVID-19, the global

[57] Ehrlich and Holdren, ‘Impact of Population Growth’, pp. 1212–1217.

population continued to increase. Meanwhile, declining fertility and slowing population growth indicate that longer-term demographic change is already under way, although its timing and consequences differ considerably between regions.[58] Neither catastrophic mortality nor an assumption of limitless population expansion provides an adequate foundation for policy.

Historical experiences of environmental stress and societal instability likewise caution against explanations founded upon a single cause. Population pressure can aggravate vulnerability, but environmental conditions, political institutions, social organisation and opportunities for adaptation help determine whether societies endure, transform or fragment.[59] In the contemporary world, high levels of consumption and environmentally damaging technologies can magnify the impact of population growth, while improved efficiency and effective governance may reduce it. Such improvements, however, must be assessed against absolute ecological outcomes rather than assumed to offset rising demand automatically.

The practical response must therefore be broader than a numerical population target. Voluntary reproductive healthcare, education and economic security can support demographic stabilisation, while cleaner energy, sustainable food systems, reduced waste, biodiversity protection and more equitable resource use address environmental pressures more directly.[60] The central challenge is not simply how

[58] United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects 2024: Summary of Results*, pp. 1–10; Msemburi et al., 'The WHO Estimates of Excess Mortality Associated with the COVID-19 Pandemic', pp. 130–133.
[59] Scott, *Against the Grain*, pp. 211–213.
[60] Intergovernmental Panel on Climate Change, *Climate Change 2023: Synthesis Report*, Geneva, IPCC, 2023; United Nations Population Fund, *State of World Population 2023: 8 Billion Lives, Infinite Possibilities*, New York, UNFPA, 2023.

many people the Earth can accommodate, but how human societies can secure wellbeing without undermining the ecological systems upon which their future depends.

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