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Supplementary Materials for the Commentary: Communicating Health of the Planet and its links to Health of People

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Supplementary Materials for:

Commentary: Communicating the health of the planet and its links to human health

This Commentary further integrates the research material in the 2019 Global Environment Outlook-6 (GEO-6) coordinated by United Nations Environment to develop an integrated burning embers diagram that can communicate how the health of the planet is affected by recent and ongoing global changes, and how that affects human health.

GEO-6 evaluated evidence from some 3880 published sources. Part A (status and trends) authors largely followed the DPSIR method, reviewing drivers, pressures, state, impact, and responses, to assess the status of each of the five earth components chosen for analysis (air, biodiversity, oceans, freshwater, and land). Authors identified the most relevant processes currently affecting each system component, discussed the linkages with other systems and, within the given space constraints, prioritized the most important factors affecting the health of the planet for the period 2019-2050 and its impacts on people. They focused primarily, but not solely, on English language peer-reviewed papers published in high-impact journals after the release of GEO-5 in 2012. Other important sources included grey literature and published reports from the World Bank, OECD, IUCN, UN agencies and Oxfam. The review structure demanded the inclusion of cross-cutting issues such as economics, gender, inequality, and human health, using similar criteria. The literature search used a “snowball effect”, identifying key sources that pointed to additional materials. The final GEO-6 report is the result of extensive research, analysis, and peer review by thematic and country experts. To translate the central conclusions of GEO-6 into easily accessible knowledge, the authors of this Commentary iteratively brainstormed on the design of the burning embers figure and on how to rank the different systems on the extent and rate of damage and reversibility in a single diagram. Clearly this assessment could be improved with better data and knowledge, and a more comprehensive expert elicitation process, but we assert that the GEO-6 process provides a valid and robust assessment of the literature on humanity’s current environmental predicament. UN Environment paid for travel to and subsistence for authors at meetings, which enabled the debate and discussion that led to this paper, but the actual research work for UN Environment’s Global Environment Outlook, and for this paper, was undertaken voluntarily.

In preparing the burning embers diagram, we used the following steps:

1. We took the literature review covering 3880 papers from the GEO as our starting point.
2. We adopt a normative position emanating from the Sustainable Development Goals which requires leaving no one behind and the furthest behind first.
3. Following the GEO thematic structure, we focus on air, land, freshwater, oceans, and biodiversity and (i) assess whether there is a risk of irreversible damage occurring locally or globally for 2018-2050; (ii) rank the impacts on the health of the planet and show the rate of system deterioration; (iii) examine the impacts on human health and wellbeing; (iv) rank which systems have the most impact on human health; and (v) where locally occurring impacts very strongly affect the furthest behind, we adjust the ranking.
4. To draw our burning embers figure, we translate the rankings 1-5 into bars with the length of the bar representing the impact: the higher the impact, the longer the bar. The darker the colours, the more irreversible an impact in the period until 2050. We emphasise the ‘furthest behind first’ by considering high local impacts, indicated by dotted lines.

Findings

The comprehensive review on atmosphere, land, freshwater, oceans, and biodiversity led to the following key insights.

Key atmospheric challenges include climate change, and indoor- and outdoor air pollution. As the Commentary explains, without ambitious policies, the 1.5°C mark will be crossed in the 2030s.¹ Beyond 1.5°C, a 2°C temperature increase and a sea-level rise of 0.4-0.6m by 2100² seems increasingly likely. Options to address climate change within safe limits are being rapidly foreclosed. Irreversibility may set in with increasing positive feedback loops; for example, increasing greenhouse gases (GHGs) increase temperatures leading to decreasing high-albedo ice cover and increasing permafrost melting which releases methane, a potent GHG, further increasing temperatures. Outdoor air pollution occurs in urban areas world-wide and exceeds WHO standards in most cities in middle- and low-income countries,³ but is reversible. Severe household air pollution in poor homes in peri-urban and rural areas of the Global South is primarily local and also reversible. Overall, the irreversibility and impacts of climate change make the atmospheric challenge very serious. Reversing outdoor and indoor air pollution will require major changes to transport, energy, and other systems, many of which will also mitigate GHG emissions.

Of the 71% of land that is usable for agriculture, 50% is dedicated to food production; of the latter 77% is used for meat production.⁴ The costs of the degrading health of land, taking account of both replacement costs and damage done, have been estimated at USD 20 trillion per year.⁵ Key issues include desertification, soil degradation and (coastal) erosion, which are locally critical, occur in rural areas worldwide, and are only partially reversible.^{6,7} Wildland transformation is locally and regionally critical, occurring mostly in rural areas in the Global South and only partially reversible within our timescales. The gulf between consumption and production spaces implies that land use change results more from demands in distant places rather than local needs. Chemical and waste pollution is also critical locally, occurring world-wide, and only partially reversible.⁸ The competing uses of land usually favour the most economically productive, not necessarily the more sustainable, use.

Freshwater challenges include slow-onset disasters such as water scarcity and drought, placing local water systems at considerable risk worldwide. Groundwater pumping occurs beyond recharge levels, is largely irreversible when applied to fossil aquifers, and is exacerbating land subsidence and related problems. Changing precipitation patterns, extreme weather events causing floods, and melting glaciers (especially in the Alps, the Himalayas and the Andes) are globally irreversible trends and linked with climate change. 90% of all disasters are water-related.⁹ Saltwater intrusion, chemical and waste pollution (including antimicrobial compounds, endocrine disruptors, plastics including micro- and nano-plastics, and nutrients) and biological pollution (the spread of pathogens) are critical locally, occurring worldwide, and only partially reversible.

Ocean health and stability is affected by melting sea ice (resulting in sea level rise), increasing water temperatures (which impact global weather patterns), biodiversity loss, including devastating coral bleaching events, and low-oxygen zones. These climate change related impacts are only partly reversible and only for some ecosystems. Over-fishing in some locations has reduced fish stocks, which is only partly reversible. Additional stressors include continually increasing chemical and plastic pollution, both of which are probably irreversible in our time-frame.

Table 1. Ranking the health of the system components of the planet (2018-2050)

	Key issues	Evaluation	Rank
Atmosphere	Climate change	Reaching irreversibility globally; rapid onset disasters world-wide: unpredictable/irreversible	2
	Indoor air pollution	Critical locally in poor households occurring in developing countries: reversible	
	Outdoor pollution	Critical locally especially in urban areas occurring world-wide: reversible	
Land	Land degradation	Critical locally, occurring world-wide, partially reversible	5
	Landscape transformation	Critical locally, occurring mostly in the Global South, partially reversible	
	Waste and chemical pollution	Critical locally, occurring world-wide, partially reversible*	
Freshwater	Slow onset disasters (water scarcity, drought)	Critical locally and regionally, occurring worldwide, predictable and partially reversible	4
	Changing precipitation patterns	Reaching irreversibility globally	
	Freshwater pollution and quality	Critical locally, occurring world-wide, partially reversible locally, partially irreversible globally	
	Fossil water extraction	Critical locally, occurring world-wide, irreversible	
Oceans	Ocean warming and sea ice melting	Reaching irreversibility globally	3
	Coral bleaching	Reaching irreversibility globally	
	Plastics	Reaching irreversibility globally	
	Fish stocks	Critical locally, occurring world-wide, partially reversible	
Biodiversity	Loss of genes, species, ecosystems	Irreversible globally	1
	Invasive species	Reaching irreversibility, occurring worldwide, critical locally	
	Illegal wildlife/timber/fisheries trade	Critical locally, occurring world-wide, partially reversible	

*There is preliminary evidence that the more than 100,000 chemicals in use are contaminating earth systems and exacerbating disease. But for most of these there has been relatively little research on the overall health impacts.

The degradation of atmospheric, terrestrial, freshwater, and ocean systems has affected biodiversity, from genes to ecosystems; there is widespread concern that we are entering a sixth major extinction event.¹⁰ Many wildlife populations are experiencing precipitous declines in abundance, species are increasingly threatened with extinction, and ecosystem productivity has declined in 10 out of the 14 major terrestrial habitats¹¹ with unprecedented biodiversity loss especially in freshwater ecosystems.¹² Insects, including pollinators important for agricultural productivity, and many other species providing key ecosystem services are in rapid decline. Extinction, despite technological genetic advances, remains largely irreversible, and the lost benefits of biodiversity are not immediately recoverable.

In our collective judgement, the pressures on biodiversity at all scales and the irreversibility of biodiversity loss make biodiversity the component of the Earth system whose health is already most

compromised¹³, followed by the atmosphere (especially climate change), oceans (sea level rise, warming and plastic pollution), freshwater, and finally land (see Table 1). Biodiversity loss and climate change have cascading impacts on oceans, freshwater, and land degradation and desertification which, in turn, affect biodiversity and climate change – such feedback loops might push the Earth system towards multiple tipping points through which planetary health deteriorates with increasing rapidity (see Table 1).

A healthy atmosphere provides clean air to breathe and a stable climate. However, widespread air pollution is the number one global environmental public health risk.¹⁴ Indoor and outdoor air pollution is responsible for some 6-7 million premature deaths annually^{15,16,17} and about USD 5 trillion in welfare losses¹⁸. This number may be an underestimate as recent estimates suggest almost 9 million deaths in 2015 attributable to outdoor air pollution alone.¹⁹ Extreme air pollution is likely to worsen in a warming world and climate change may impact human health directly in multiple ways, including through increasingly extreme weather events, with higher temperatures affecting especially children and older people world-wide and indirectly through displacement globally.²⁰

Land provides homes, livelihoods and food for people and is essential for their well-being. Land degradation is affecting 3.2 billion people globally in terms of reduced food security, loss of livelihoods and displacement.²¹ Deforestation is displacing people, and leading to zoonotic disease outbreaks (see below), which, when coupled with mono-cropping, can also lead to food security issues. Chemical pollution exacerbates the rise of non-infectious diseases especially in rural areas, occurring world-wide, affecting men and women differently.^{22,23} The displacement of indigenous peoples and local communities, the inability of women in many parts of the world to inherit land, and falling food availability at affordable prices increase food insecurity and exacerbate these negative health effects, and increase health inequalities.

Human health relies on access to clean freshwater and predictable freshwater flows. Disasters (slow-onset - drought, water scarcity; and sudden floods) have a direct impact on human health and hygiene, and indirectly affect livelihoods and food security through putting both rain-fed and irrigated agricultural systems at risk. This leads to displacement and conflicts, especially in poor rural areas of the Global South. Glacier melt and unsustainable groundwater extraction will also have long-term effects on water and food security, lives and livelihoods. Unsafe water, sanitation and lack of handwashing facilities kills about 1.7 million people annually worldwide. Plastic particles including micro- and nano-plastics are now evident in freshwater, with as yet unknown health effects. Without effective counter-measures, antimicrobial resistance stemming from antibiotics and other chemical compounds is predicted to become a leading cause of death by 2050.²⁴ Endocrine disruptors which are now found in freshwater worldwide reduce human male fertility, and lead to the feminization and lower fertility of fish populations²⁵, as well as other species, with an irreversible impact on the environment and biodiversity.

Table 2. Ranking the impact of system components on human health (2018-2050)

	Key issues	Evaluation	Rank
Atmosphere	Climate change including temperature rise	Displacement high globally; death globally; loss of homes and livelihoods; more premature deaths of older people and children	1
	Indoor air pollution	Non-infectious disease; very high mortality/morbidity in poor households especially to women and children; locally occurring in the Global South	
	Outdoor pollution	Non-infectious disease; very high mortality/morbidity in urban areas especially to children and older people; occurring worldwide	
Land	Land degradation	Displacement regionally occurring world-wide; loss of homes and livelihoods especially for poorer people	5
	Wildland transformation	Displacement regionally occurring in the Global South; loss of homes and livelihoods	
	Waste and chemical soil pollution	Non-infectious disease; mortality, morbidity especially in rural areas; occurring world-wide	
Freshwater	Slow-onset disasters (water scarcity, drought)	Affects health, hygiene, food security, displacement and conflict; very high regionally especially for children, occurring in the Global South; loss of homes and livelihoods	2
	Changing precipitation patterns	Affects food security, displacement, conflict, high regionally; loss of homes and livelihoods	
	Waste and chemical water pollution (including antibiotics and endocrine disruptors)	Infectious & non-infectious disease; mortality, morbidity; anti-microbial resistance; endocrine disruptors affect fertility of many species, as well as human male fertility	
	Fossil water abstraction beyond recharge	Affects food security, displacement, conflict	
Oceans	Ocean warming and sea ice melting	Death from extreme weather events, death and displacement as a result of sea level rise	4
	Coral bleaching	Affects food security (protein intake of poor), livelihoods of small fishers, tourism	
	Plastics	Could potentially lead to health risks	
	Fish stocks	Affects food security (main source of protein intake for many people including the planet's poorest)	
Biodiversity	Genes, species, ecosystems	Affects food security and income; psychological health and cultural identity; zoonotic infectious diseases affecting more vulnerable people; species affected by endocrine disruptors	3
	Invasive species	Spread of pathogens/infectious disease; food insecurity; cultural impacts of key species lost; very high locally, high globally	

Healthy coasts and oceans provide direct and indirect work for over 1 billion people and protein for 3.1 billion people. Coral reefs provide services valued at USD 29 billion²⁶, fisheries provide services valued at about USD 253 billion employing 58-120 million people²⁷, and provide essential affordable protein for

poor people. With declining fish populations and coral reefs and increasing marine litter, employment in coastal fisheries and tourism will also decline rapidly. Sea level rise may present an existential threat to coastal lives, affect livelihoods, and displace people.

Biodiversity loss has profound health impacts. The decline in genetic diversity reduces adaptive potential to global change, loss of species including pollinators and degradation of ecosystems is affecting food security, decreasing income, and increasing zoonotic disease (which is 60% of infectious disease).²⁸ More data is needed on how this relates to infectious disease from water pollution. Economic costs are large, with pollinator services alone estimated at USD 200 billion annually.²⁹ Invasive species may enrich local biodiversity at least temporarily, but potentially disrupt local economies, lives and livelihoods, and result in cascading extinctions of native species with attendant impacts on human health and well-being. The illegal wildlife trade feeds into local violence in biodiverse-rich areas, with harm to human health.

We judged that the high morbidity from air pollution has the highest impact on human health. Next come the severe freshwater impacts of too little water (through drought), too much water (through flooding) or chemical pollution conveyed through the water cycle. This is followed by the displacement of people from their lands, then the effects of loss of biodiversity and the losses from the oceans. The dotted lines try to account for the impacts on the poorest, and their placement was particularly challenging. About 70% of the world's poorest people depend directly on ecosystem services for their survival; hence, the disruption of these services disproportionately affects their wellbeing, and this is inadequately captured in national economic indicators. Furthermore, about 25% of global disease and mortality can be related to poor environmental conditions; but whether this number captures the fact that zoonotic diseases are around 60% of infectious disease is unclear. Unhealthy living circumstances, disasters and freshwater scarcity have also displaced three times as many people as conflict: e.g. in 2016, 24.2 million people were displaced in 118 countries by sudden-onset disasters.³⁰

In terms of total impacts on human health, we conclude that air pollution has the highest impacts, followed by freshwater pollution, biodiversity changes, and finally damage to oceans and coasts and then land (see Table 2). We have integrated the information on the health of the planet and human health in the Figure in the commentary.

Several conclusions follow this path of analysis. First, there is ample evidence of the need for urgent action, requiring a discussion by policymakers on how to prioritize key planetary health issues. We recommend future integration of studies of public health and social determinants of health with environmental determinants, in order to develop a more definitive assessment.

Second, environmental protection is in the economic interest of states because of the huge health dividends to society. This finding complements a report arguing that investments in human health and better lifestyles in OECD countries benefit the environment; and which also finds that a healthier diet (e.g. less meat for those who have high meat based diets), sustainable cities, and non-mechanised transport offer potential to enhance human health while promoting a healthier planet and mitigating climate change.³¹

Third, a healthy planet cannot be achieved without tackling social division, inequality and environmental injustice within and between countries. Richer countries and rich people worldwide contribute disproportionately to global environmental degradation, yet impacts are felt more by those furthest

behind. Adapting to higher ambient temperatures and climate change, and reducing disaster risks, is less of an economic and health burden for the wealthy than for the poorer and more vulnerable populations. But the irreversible impacts of environmental degradation will affect us all.

Fourth, it is often cheaper in financial terms to make current economic development more environmentally sustainable, rather than to continue along the common trajectory of seeking to ‘grow now, clean up later’. The urgency of such rational decisions is strengthened by the irreversibility of certain environmental changes, which could hamper or prevent later clean-up.

Future assessments may wish additionally to consider the ease with which steps can be taken to reverse the environmental degradation. While the present paper seeks to show damage to the planet and consequent damage to human health, it does not analyse where it is difficult and where it is easier to bring about change. Furthermore, understanding of the major earth cycles (eg. carbon, water) is increasing rapidly, and their future assessments also need to consider the speed with which changes are occurring in these cycles. Humanity is engaging in an arms race of knowledge versus impacts.

Policymakers have been reluctant to act on policy suggestions coming from analyses such as these, yet developing guidance for policymakers was a specific mandate of GEO-6 at the request of Ministers at the second UN Environment Assembly. Given the urgency of the environmental situation – emphasised also at the 2018 climate negotiations in Katowice, Poland – it is essential that policymakers treat the warnings in GEO-6, as summarised in this article, with the seriousness they deserve, and use this knowledge to fundamentally change the direction of human economic and social development. This information and conclusions from reports such as GEO-6 need to be communicated to all ministries, including ministries of Health, Economy and Finance, and incorporated into government and non-governmental organisations addressing also health, rural development, urban planning and social affairs. The good news is that investing in the environment generates benefits for both human health and the economy. A healthy planet is an essential prerequisite for healthy people.

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