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Climate change, food systems and population health risks in their eco-social context

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ABSTRACT

The establishment of ecological public health as crucial to modern public health is overdue. While the basic concepts have been gestating for decades, receptivity within broader public health has been limited. This position is changing, not least as the population-level impacts of climate change and, more broadly, of limits to growth are emerging from theory and forecasting into daily reality. This paper describes several key elements of ecological public health thinking. These include the 'environmental' risks to human health (often systemic and disruptive, rather than local and toxic) posed by climate change and other forms of adverse global environmental change. Closer recognition of the links between social and environmental factors has been urged – an 'eco-social' approach – and, relatedly, for greater co-operation between social and natural sciences. The authors revisit critics of capitalism who foresaw the global capture and transformation of ecosystems for material human ends, and their resultant despoliation. The perennial call within public health to reduce vulnerability by lessening poverty is more important than ever, given the multifactored threat to the health of the poor which is anticipated, assuming no radical strategies to alleviate these pressures. But enhanced health security for the poor requires more than the reconfiguring of social determinants; it also requires, as the overarching frame, ecological public health.

Introduction

Global environmental change, of which profound alteration to the climate is but one aspect, is now widely accepted as a reality. This new phase of Earth system history has been called the 'Anthropocene' – an era in which the collective force of one species, it is recognized as changing the planet's operating system. Here, the social causes of the Anthropocene, and manifestations including climate change, the world food system, and the prospects for health are briefly considered.

Climate change is part of a larger syndrome of systemic environmental changes, including stratospheric ozone depletion, biodiversity losses, ocean acidification, disruption of the global cycling of nitrogen, phosphorus and sulphur, and

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depletion of fertile soils, freshwater supplies and marine productivity. These great changes, all of which intensified in the latter third of the twentieth century (though some only became evident in this time), are unprecedented at global scale. They reflect the excessive, escalating, demands that the still-expanding global human population is now putting on the biocapacity of the planet – the capacity to generate, replenish and absorb. The best approximate estimate is that, globally, people are living well beyond Earth's means, using 1.5 times as much as can be supplied on a continuing basis. That move into deficit ecological budgeting emerged just 35 years ago, and is increasing every decade.

In consequence, Earth's long-term human life support system is faltering as people subsidize their ways of living by raiding nature's capital stock; and so the natural resource base shrinks.[1] Average global life expectancy and population size continue to rise, and mainstream forecasts are for these trends to continue for decades to come. But while some of this increase is due to technological improvement, a large fraction of these phenomena has been underwritten by the combustion and consequent degradation of irreplaceable planetary material – especially fossil fuel.[2] The biosphere has been altered enormously in order to meet human needs and wants, but its transformation risks exceeding a threshold, beyond which the health of human populations will decline. The risks that have been faced are likely to accelerate over the coming decades and beyond. They will, inevitably, impinge unevenly in populations around the world, reflecting differences in geographic region, local physical environments, economic resources, levels of frank poverty, know-how and governance. Many of the energy-intensive technological choices, production methods and commercially-cultivated consumer behaviours that erode human health, especially in richer modernising populations, are major contributors to global greenhouse gas emissions.

Climate change and type II diabetes are both substantially the outcome of resource over-consumption – and they are linked. Fossil fuel-based energy, by far the dominant source of the human-generated greenhouse pollutants, powers the basic needs (lighting, hot water, communications, most of the public transport and the industrial food system), labour-saving devices (mechanized industrial production, private cars, ride-on lawnmowers), and production and distribution of the superfluous material goods that those with abundant money (or credit) buy. Labour-saving devices at home and work, private transport, and consumption of increasingly processed diets high in energy, especially fats and sugars, have been major contributors to the rise in obesity and subsequent type II diabetes. Solar and other new forms of renewable electrical energy, which preserve fossil fuels and which do not worsen climate change, are growing rapidly, but from a very low base.[3]

At core these are ecological issues, referring to the ways that societies live. They do not conform to conventional 'environmental health hazards' in the same way as localized toxicity or physical (e.g. radiation) injury, rather they signify the weakening of global/regional life-support systems which underpin human health and survival. The current system of bio-spherically charged production and consumption is much more complex, and in this sense is hard to classify as a public health issue as the authors explore in the coming sections.

Climate change

The slow pace of public understanding of human-caused climate change appears to have historical analogies in heliocentricism and evolution, previous revolutionary shifts in human consciousness for which acceptance was delayed not only by denial and suppression but by their cognitive complexity. The realisation that this species, collectively, is a driver of planetary change appears too large a cognitive challenge for many people. Recognition is further delayed by a coalition of forces organized particularly by those who profit from the burning of fossil fuels,[4] using denialism, well-known in public health circles from previous campaigns to obscure the recognition of health hazards from tobacco to asbestos.[5]

Even so, doubts about the reality of climate change are fading with a growing list of governments introducing policies to curb carbon emissions, to adapt to increased warming and torrential downpours. The world has warmed by around 0.6 °C since the 1970s, and has done so much faster at high northern latitudes (northern Norway has warmed by 2 °C). Current modelled estimations by international climate science indicate a rise of 3–5 °C by 2100, and twice that in the Arctic region. This is well-over the 2 °C 'guardrail' formerly accepted as the maximum tolerable.[6] As global temperatures, adjusted for year-to-year modulations due to natural forcings (the El Niño/La Nina cycle, volcanic emissions and minor variations in solar activity), continue to rise,[7] there is some partial offset by aerosols of anthropogenic origin, such as from the burning of coal and biomass, which slow climate change, but harm health through non-climatic pathways.[8] While most of the energy released from this combustion benefits human well-being, some is lost through inefficiencies, including energy transmission, poorly insulated dwellings and the use of private instead of public transport,[9] and through various wasteful uses.

The influences of climate change on health outcomes are predominantly on whole communities, even whole populations. Certainly, individuals and sub-groups are often more or less vulnerable than the group average, but the main point stands: the impacts of climate change are of an *ecological* kind. At their simplest they result from exposures that impinge on all people in a community (such as heatwaves or exacerbated air pollution) and at levels that also influenced by characteristics of the shared living environment. Many other risks result from climate-related changes in environmental conditions, ecosystems, the distribution of species and, hence, in the internal relations and dynamics within that complex. Two major examples are: first, changes in infectious disease patterns, reflecting altered microbial activity and distribution, human contact with animals, microbes and with one another and changes in infection transmission probabilities; and second, changes in food yields and hence in food prices, availability, nutritional states and child and adult health. It is no surprise that the first two of the biblical Four Horsemen of the Apocalypse were Pestilence and Famine. There are many other indirect, often deferred and diffuse, health impacts of climate change – including the oft-overlooked anxieties, stresses and frank mental health disorders that result from extreme weather events and their resultant losses; from

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displacement and, often, migration; and, in rural communities rich and poor, from agricultural failure, family hunger and loss of livelihoods.

Types of climate-related health impacts

There are several ways to categorize the health impacts from climate change.[10] Three distinguishable pathways of influence (physical, biological and economic) on well-being, health and survival are illustrated in the following diagram (see Fig. 1).

Butler and Harley[10] classify primary (or direct) impacts as those resulting when communities and particular occupational groupings are directly exposed to extremes of weather: heat, rain (and flooding), hail, snowstorms, wind and bushfires. Injuries, deaths and infections occur. On a broader front, though one step removed, there are relatively direct impacts that follow soon after the event, affecting mental health, jobs, livelihoods, community morale and other aspects of human wellbeing.

They suggest that secondary health impacts arise less directly, mediated by the environmental and ecological consequences of changes in climatic conditions. These include, as mentioned above, changes in the rates, range and seasonality of various infectious diseases and declines in food yields and human nutrition, if the latter are at a modest scale. Another ecologically-mediated health consequence results from the generation and dispersal of various aeroallergens from pollens and spores, increasing the risks of asthma, hay fever and other allergies.[12]

Changes in climate, including diminished regional rainfall and shrinkage of mountain glaciers can reduce flows of freshwater, thus compromising domestic hygiene, drinking-water safety, local food yields and personal hydration. Floods, also predicted as more likely due to climate change, can also compromise water quality, including by damaging sewerage infrastructure. Another secondary health consequence of climate change has arisen from the increasing salinity of coastal groundwater (well-water) because of sea level rise. Epidemiological studies in low-lying coastal Bangladesh have shown the often substantial increase in daily salt intake to be a very likely cause of the observed increased prevalence of raised blood pressure in coastal rural communities with high-salinity well-water. This then apparently predisposes to problems (including toxaemia) in late-stage pregnancy.[13]

Tertiary health impacts arise via an indirect and more complex and protracted causal chain. They emerge more slowly and affect the fundamental supports of social relations and institutions and human wellbeing, health and survival. These are less easy to study in a specific and quantitative way (and are therefore of less interest to practitioners of conventional epidemiological research). Examples include emotional anxieties and behavioural disturbances in young children becoming apprehensive or fearful about the future; the wide-ranging health consequences (both negative and positive) of displacement and relocation of communities and families due to combinations of rising population pressures and climatic and environmental adversity; and the more ominous prospect of increases in tensions and conflicts over dwindling natural resources, including arable land, freshwater supplies and space for settlements and daily living.[14]

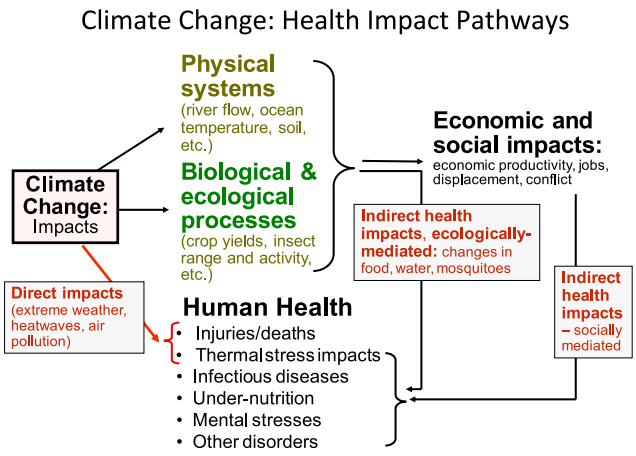

Fig. 1 – Schematic diagram of the main categories of climate change-influenced health outcomes and the three associated pathways (see red boxes, and associated text). Figure from Ref. 11. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Eco-social disruptions: supermarket global value chains

Moore argues that the contemporary 'crisis' of the world food system has co-evolved with increased eco-social disruption over the last three centuries.[15] Today, every aspect of the world food system contributes to environmental degradation. Agricultural and aquacultural production,[16] for example, have been shown to contribute the greatest share of food system-related greenhouse gas emissions and toxic waste, while a significant amount of food wastage occurs in affluent households.[17,18] Consistent with the logic of capitalism, as recognized by Marx, the world's major food retailers today exert a profound global influence over agricultural and human ecologies. This is apparent due to the enormous scale of their operations, their demand for high volumes of commodities, and their increasing control not only over global food supply chains but increasingly also over food cultures.

Though a relatively recent innovation, even in the developed world (about seventy years), supermarkets and the social and cultural forces (the female labour force's demand for convenient meal preparation, for example) which underpin them have effectively dislocated food production and exchange from both their biospheric and socio-cultural contexts. As P. McMichael and Friedmann[19] have observed, supermarkets:

> *... are vehicles of social and ecological reorganization: transforming historical relations embedded in local food systems, crop varieties and knowledges, rural communities, peasant producers and small farmers, waste recycling systems, biological processes,*

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hydrological cycles, and a variety of urban experiences and cultural lifestyles (p. 297).

One hundred and fifty years ago, Marx[20] described the multiple impacts of the usurpation of agrarian systems by industrial agriculture as 'the metabolic rift'. Eighty years later, Polanyi prophesised:[21]

To allow the market mechanism to be the sole director of the fate of human beings and their natural environment . . . would result in the demolition of society. … Nature would be reduced to its elements, neighborhoods and landscapes defiled, rivers polluted, military safety jeopardized, the power to produce food and raw materials destroyed (p73).

Both insights are being realized. Under the agrarian (largely pre-urbanized) system, direct feedbacks between nutrient cycles, plant and animal yields, and human life and death were clear. In contrast industrial and urban food systems are now characterized by 'ecologies at a distance': where nutrients, labour power and environmental hazards are exchanged globally.[22,23] Facilitated by neoliberal market dogma, in the context of increasingly depleted agro-ecologies and saturated markets, the commodified food system, now under supermarket chain control, has been able to expand its territorial reach to hunt for and exploit surviving nutrient-rich environments and to colonize new middle-class commodity markets. This expansion has involved energy intensive logistical systems.[24]

Historically, the system regulating food supply and demand dynamics was a local culturo-environmental ecology: the intergenerational sharing of food knowledge, preferred ingredients based on seasonal and local conditions and cooking skills.[25] The cheap, industrial food supply has broken this system to be replaced by the rise of the culture of convenience which, alongside product 'choice', has been championed by supermarkets as emblematic of modern consumerism. In shaping the nature and content of global food supply networks and culinary cultures, supermarkets are not simply consolidating the dislocation between society and nature, they are also contributing to a profound disturbance in human metabolism in the direction of encouraging the overconsumption of food and energy.[26–28]

Misperceptions of 'health' (especially in modernized wealthier societies)

The *ecological* approach to studying, understanding and acting on climate change-related health risks and impacts can be appreciated by comparison with the prevailing view of 'health' in modern western cultures is instructive. In those societies a narrow, individual-focused, and often misleading model of health and its determinants prevails. This model reflects in part the powerful recent influence of neoliberalism, viewing individuals as free agents, responsible for their own actions and consumer choices. Individuals are thus deemed to be, in large part, the arbiters of their own health.

The corollary of this view is that people are therefore less inclined to ask how the community's shared way of living and the conditions of the ambient environment influence the pattern and rates of disease.[29] That question calls for a change in the popular mindset, a capacity to think within an ecological frame that recognises the importance of population-level relationships between shared environmental circumstances (animate and inanimate), local culture, and how the interplay between those then influences patterns of behaviour, consumption and social interactions. The ecological perspective – understanding the interplay between human communities, habitats, culture, food ecosystems, microbial activity, and the prevailing climate and environment – differs fundamentally from the prevailing assumption, is the primary determinant of health. This task is conceptually challenging for those trained in social environments dominated by neoliberalism, not only for the general public, but also for many health leaders, even within public health.

The contemporary public health problem of rising rates of obesity underscores the need to apply an ecological perspective. How does the experience of the community-at-large within its shared living environment, social-cultural milieu and the dominant economic forces affect patterns of behaviour, choice and health outcome? The fundamental source of the obesity problem is not because human behaviour has recently become more deviant, or because there has been an increase in the prevalence of deleterious genes for fatness (new variant genes are periodically identified in caged rats fed on a 'cafeteria diet' by enthusiastic laboratory scientists – and the celebrated as another breakthrough by ill-informed media comment). No, it is because the context and pattern of daily living and commercially-promoted consumer choices has changed greatly in recent decades such that, *on average*, people are consuming more food energy than they need for their now diminished energy output in a modern labour-saving world. Reductions in nutrient and calorie-robbing parasitic infectious diseases may also be a factor.

The problem of rising obesity incidence has its roots in the distortion of human ecology that is a bed-fellow of modernisation and energy-subsidised living. These insidious contemporary imbalances are embedded in current ways of living – and not readily visible or meaningful to those who think in narrow downstream terms about the cause of obesity in individuals. But this is, mostly, not a problem of errant or metabolically unusual individuals; it is a risk-increase shared by 'the herd'; it is *ecological*.

There is also an issue of over-shoot and lag. Since the onset of the Holocene, the comparatively stable warm period over about ten millennia since the end of the last Ice Age, and its associated progressive introduction of agriculture, most farming communities have struggled with periodic food scarcity, with many people experiencing regular hungry seasons and occasional famine. In the last century, the spectre of hunger has receded for most people, replaced by calories that are abundant and cheap by historical standards. The forces that led to this abundance for most – agricultural technology and capitalism – have been widely accepted and supported. This is not only because the problems of hunger and undernourishment were viewed as most important but also because humanity had – and still has – limited experience of large-scale over-nutrition, and even less awareness that this too could undermine optimal health. In fact, unless this trend is

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slowed, life expectancy in developed countries may decline[30] – even if other determinants, such as sufficient affordable energy and a sufficiently benign climate can be maintained (see Fig. 2).

A major challenge then is to improve the nutritional composition and available variety of food at an affordable price, in ways that lead to lower rates of obesity and to a fairer distribution of health and its determinants. Social recognition of this second challenge lags; it is as if most populations still think that caloric abundance by itself will bring health.

These tasks are made even more difficult not only by the continuing ascendancy of neoliberalism, but by tightening limits to growth, manifest as persistently high energy prices, and the associated economic recession as so much purchasing power is diverted to obtain hidden and visible energy.[31] Climate change and rising energy prices is also steepening the challenge of food security.[32,33]

Vulnerability: differences in health risks between and within populations

The levels of health, public health resources and access to health care remain very unequal, both between and within populations and especially between the world's rich and poor. The UN Millennium Development Goals sought to reduce disparities in poverty, hunger, malnutrition, maternal mortality, diarrhoeal diseases, malaria, HIV/AIDS, tuberculosis, and unsafe drinking water. Yet, the adverse impacts of climate change and other manifestations of limits to growth[34] on environments, poverty levels and health risks may impede these achievements and increase health disparities.[35,36] Communities and groups in many low-income countries, and especially those in over-crowded slum-dwelling settings, will be at particular risk.

Richer countries also harbour differences in vulnerability. In the United States impacts of the 1995 heat-wave in Chicago and the 2005 Hurricane Katrina in New Orleans on injuries, health disorders and deaths differed markedly between ethnic and socio-economic groups. This pattern is likely to be documented following Hurricane Sandy in late 2012, in which some populations were trapped for many weeks in high rise flats, cut off from electricity and fearful, or unable to venture down dark windowless staircases, in order to refresh supplies. The poor and residentially disadvantaged suffered the most. In Australia the particularly vulnerable groups include:

- rural communities likely to be exposed to long-term drying conditions;
- elderly and frail persons, especially in relation to heat-waves, floods and fires;
- coastal communities facing storm surges and altered patterns of cyclones;
- remote communities of indigenous Australians facing more frequent extremes of heat, drying, water shortages and the loss of traditional plant and animal food species; and
- people who live in regions where climate-sensitive infectious diseases may tend to spread, including likely greater exposure in northern Australia to several mosquito-borne infections (dengue, Ross River virus disease and others).

Around much of the world, gender differences in health risks from climatic conditions and fluctuations are a basic

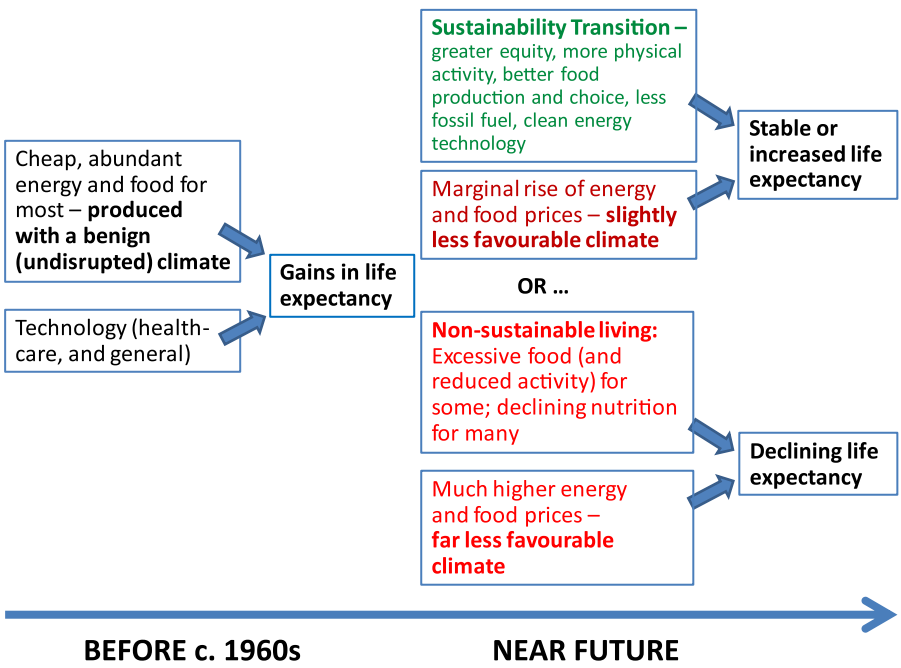

Fig. 2 – Despite HIV/AIDS, global life expectancy has increased in recent decades; many expect this trend to continue. However, excessive caloric intake is already contributing to increased diabetes rates, which some experts predict will lower life expectancy within decades.[30] Far less recognized is the possibility that steep rises in energy prices and a less favourable climate could also lessen life expectancy. On the other hand a widespread 'sustainability transition' (see text) could greatly mitigate or even reverse the decline in life expectancy which otherwise appears inevitable.

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aspect of vulnerability.[37] These differences reflect physiological, behavioural and social-cultural influences. In European populations in general, women are more likely to die in heatwaves, while among isolated and unmarried persons men are at greater risk. In poorer countries, droughts and water shortages cause increased health risks in women and girls because of nutritional deficiencies and the burdens of travelling further to collect water. In countries everywhere, suicide rates among male farmers typically rise during severe or prolonged droughts.[38]

Rural communities on marginal land in parts of Sub-Saharan Africa and South Asia will be particularly vulnerable to declines in rainfall.[6] Rice farmers on the east coast of Vietnam face a likely increase in crop-destroying typhoons.[39] Crowded slums and shanty towns where hygiene is difficult will be easily overwhelmed by more intensive rainfall events that then enhance transmission of diarrhoeal diseases, including cholera and dysentery, and enhance mosquito breeding. Many small island states, along with coastal Bangladesh and the Nile Delta, are at risk from sea level rise causing inundation, increasingly salty groundwater, and reduced harvests.[40,41]

As the world gets warmer, some of these vulnerability differences will lessen as thresholds for protective strategies and structures in richer populations begin to be breached. Human-induced climate change is a *global* problem but, as discussed earlier, local impacts are modulated by local conditions. The world remains a very uneven place: poverty persists widely; population growth rates differ greatly between extremes (e.g. Japan and Nigeria); geographies and meteorological systems differ between regions. Even so, as climatic stresses increase everywhere, some, perhaps much, of the rich–poor difference in vulnerability will lessen, particularly as the more substantial protective adaptations of advantaged populations approach limits or thresholds.

The OECD[42] has argued that the hyper-connectivity that characterizes modern wealthy urbanized populations, with many types and levels of integrated infrastructure increasingly dependent on shared access to energy sources, electronic connections, efficient communications and financial flows, renders these societies vulnerable to extremes of climate-induced damage. Remember the Y2K scare, the global financial crisis of 2007 and, now, the multi-infrastructural damage and failure in and around New York in late 2012 when Superstorm Sandy struck.

Further, in various respects modern populations are also more *biologically* susceptible to climate-related health risks than were simpler communities present and past. For example vulnerabilities are heightened by:

- Population ageing (longer life expectancy): susceptibility to heatwaves, physical extreme events, infectious diseases;
- The marked rise in prevalence of underlying non-communicable diseases (cardiovascular, metabolic, respiratory): susceptibility to heatwaves (strokes, heart attacks, respiratory failure) and other stresses;
- High-temperature in outdoors or in enclosed sweat-factory workplaces: heatwave susceptibility, dehydration – kidney damage;
- Urban-living and the Urban Heat Island effect: increased heatwave exposure/vulnerability;
- More prevalent allergic disposition (due to unnaturally high levels of childhood hygiene distorting the maturation of the immune system): risk of hay fever and asthma from increases in aeroallergens;
- Infectious disease risks due to more frequent exposure of immunologically *naïve* populations to the range extension of pathogenic microbes; and
- The high number of factory and agricultural workers in environments that lack air-conditioning and/or adequate access to drinking water, and the bi-directional co-dependency between their productivity and the global economy.[43,44]

A recent study in Australia illustrates the relevance of an ecological approach to the task of raising a community's psychological life satisfaction by focussing on promoting connectedness within the community.[45] Human communities mirror the fact that viable ecosystems have beneficial internal connections. The study found that overall life satisfaction comprises satisfaction with connectedness and satisfaction with efficacy. Both are strongly related to overall life satisfaction. This is helpful to know because it is difficult to raise individual or community overall life satisfaction directly – part of the looming adaptation challenge of increasing community resilience to climatic and environmental stresses. Increasing internal connectedness and cohesion then leads to positive health benefits.

While public health has a clear role to play in shaping adaptive strategies, the primordial prevention strategy is to arrest climate change (and the other global environmental changes). That primordial strategy is not a task specifically for the health sector, but for society at large, via shared understanding, the merging of sectoral interests and agendas, shifts in priorities, bold policy and community engagement/action.

Conclusion

The signs of human-induced climate change and other aspects of 'planetary overload'[46] are at a relatively early stage, yet sufficiently apparent to cause great concern to an increasing range of commentators.[47,48] Considerations of likely social benefit and moral priority mandate that adaptive strategies to lessen the resultant health risks should be weighted towards high-vulnerability groups. But this is easier said than done, in light of the great and growing power of corporate self-interests and the tactics used for political survival in modern societies.

Truly radical changes are needed to achieve the global sustainability transition.[49] This is an inter-related set of cultural, technological, social and economic transformations, required on a global scale in order to enable a decarbonized energy system, foster a green economy, and implement other necessary changes. This message is also central to *Ecological Public Health*.[50] It seems a tall order,[51] but other beneficial upheavals in the world system have occurred over short periods. There may still be time to complete the sustainability transition, but its rate needs to be accelerated; greater

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awareness by public health practitioners will contribute to this.[34,52]

Public health research has taken an important step forward over the past two decades in studying and clarifying the profound role of social, cultural and economic conditions in the determination of states of health in populations and its uneven distribution between sub-populations. Nevertheless, it cannot continue to pursue the conventional basket of interventions: local environmental/social monitoring, risk factor research, community life-style education, and preaching about 'social determinants' which are widely misunderstood to mean more equitable distribution of incomes and material assets. Many of the prominent non-communicable disease problems are the downstream consequence of basic distortions in human ecology, as the discussion of food system production and consumption dynamics makes clear. There are bigger risks on the horizon than health behavioural causes, variations and outcomes, and public health must now become a team-player in a much larger team adapting its teaching and training to an impending population risk-laden world.

What public health brings to policy engagement is information about health risks and impacts. Beyond that, its primary role will be to ensure that much of the regrettably necessary adaptation is done well: optimal targets, good cost-benefit profiles, non-stigmatising programs with as many co-benefits as is possible. The field must share 'war cabinet' engagement with all other sectors, so that various sectoral efforts do not contradict or undermine agreed-upon change principles. Finally, public health can contribute to addressing the residue of mutual indifference, even hostility which still exists between the social and the natural sciences as they compete for supremacy, too often discounting the relevance of the one party's research and theory domain to the other.

Popularized by CP Snow's oft-cited 'Two Cultures'[53] this restrictive divide has attenuated in recent years.[54] But traces survive, including resistance by some 'social determinants of health' proponents to the recognition of the profound threat to the health and survival of populations that ongoing degradation of the biophysical systems of the planet represents. The risks to climate system and Earth's ecosystems together constitute essential life-support foundations upon which humans and other species depend, and which are now endangered.[55]

The agendas of the social and natural sciences must now be brought together, equitably and synergistically.[35] The struggle to achieve the Millennium Development Goals shows that the elimination of specific major categories of health problems is impossible without commensurate attention to the declining environmental conditions and the persisting inequalities in conditions of daily living. The authors will not be able to underwrite and maintain the health of future generations if they cannot, now, incorporate a new *ecological* understanding and approach into the research, practice, advocacy and participatory and cross-sectoral policy development.

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