Exploring Solutions to our Planetary Dilemma

Climate Change, Energy Transitions and the Need for the Low-Carbon Investments

An Annotated Bibliography
for the University of Waterloo Board of Governors

December 2017

Across the planet evidence from a number of sectors is mounting that supports the position that climate change is having a devastating impact on our human health and planetary systems, and that ethically, economically and environmentally action is needed. This research also shows us that not only is it possible to act in ways that preserves our planet, these actions align with the fiduciary responsibility to see the University of Waterloo's investments do well.

This annotated bibliography shares just a small number of papers documenting the recent evidence of climate change induced impacts, of economic and environmental transitions already underway, and of the financial benefits that can be attained by taking action.

We share this information with you because we are incredibly concerned for our future, and because it is time for the University of Waterloo to bring our practice in the world in line with what we learn in our classrooms. You are in a position to act, and to make a difference. We hope you – and we – can be proud of your decision on fossil fuel investments, what that means for the University of Waterloo, a sustainability leader, and what it means for our planet.

In line with the 68 University of Waterloo faculty who wrote to President Hamdullahpur and Members of the Board on February 1st, 2016, Fossil Free UWaterloo shares this information with you, asking you explicitly to consider the impact of climate change when you make your decision about ESG commitments. We also ask you to:

- Assess the financial risks posed by climate change to the University of Waterloo's endowment and pension plans,
- Commit to no new investment in fossil fuels, and
- Develop a strategy to divest the university from holdings in the fossil fuel industry. We call on you to ensure that these funds are divested completely in the next five years.

We share this with you in hope – we all must do what we can. Now it is your turn to act.

Fossil Free UWaterloo
December 2017

Ethical Responsibility to Act

"Climate justice refers to the disproportional impact of climate change on poor and marginalized populations, while climate equity refers to who should bear the burden of responsibility for addressing climate change.

These twin concerns have both intranational and international dimensions. Climate change will negatively and disproportionately impact poor and marginalized people *within* national borders as well as cause conflicts *between* nations, regions and cities that are more or less vulnerable to climate disruptions."[1]

- William Lynn
  Research Scientist, Clark University

Key Themes in this Annotated Bibliography:

Climate Change and its Impacts on Ecology and the Environment

Climate Change and Health

Energy and Sustainability Transitions

Sustainable Finance

[1] The ethics of climate change: what we owe people – and the rest of the planet. 2015. Retrieved from http://theconversation.com/the-ethics-of-climate-change-what-we-owe-people-and-the-rest-of-the-planet-51785

Climate Change and its Impacts on Ecology and the Environment

"For all the sound and fury of climate change denialists, self-deluding politicians and a very bewildered global public, the science behind climate change is rock solid while the impacts – observed on every ecosystem on the planet – are occurring faster in many parts of the world than even the most gloomy scientists predicted.

Given all this, it's logical to assume life on Earth – the millions of species that cohabitate our little ball of rock in space – would be impacted. But it still *feels* unnerving to discover that this is no longer about just polar bears; it's not only coral reefs and sea turtles or pikas and penguins; it about practically everything – including us. … "I was not surprised," [Brett] Scheffers said of his research. "But I was alarmed. The extent of impacts is vast and has impacted every ecosystem on the Earth.""[2]

- Jeremy Hance
  The Guardian

Bindoff, Nathaniel, and Peter A. Stott. (2013). Detection and Attribution of Climate Change: from Global to Regional. Chapter 10. International Panel on Climate Change. Retrieved from https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter10_FINAL.pdf.

Executive Summary

More than half of the observed increase in global mean surface temperature (GMST) from 1951 to 2010 is very likely due to the observed anthropogenic increase in greenhouse gas (GHG) concentrations. The consistency of observed and modeled changes across the climate system, including warming of the atmosphere and ocean, sea level rise, ocean acidification and changes in the water cycle, the cryosphere and climate extremes points to a large-scale warming resulting primarily from anthropogenic increases in GHG concentrations.

Solar forcing is the only known natural forcing acting to warm the climate over this period but it has increased much less than GHG forcing, and the observed pattern of long-term tropospheric warming and stratospheric cooling is not consistent with the expected response to solar irradiance variations. The Atlantic Multi-decadal Oscillation (AMO) could be a confounding influence but studies that find a significant role for the AMO show that this does not project strongly onto 1951–2010 temperature trends.

This report documents the associated impact and changes across earth systems, including ocean temperatures and sea level rise, ocean acidification and oxygen change, the water cycle, cryosphere impacts, climate extremes, and atmospheric circulation.

[2] Climate change impacting 'most' species on Earth, even down to their genomes. 2017. Retrieved from https://www.theguardian.com/environment/radical-conservation/2017/apr/05/climate-change-life-wildlife-animals-biodiversity-ecosystems-genetics

Ceballos, G., Ehrlich, P. R., Barnosky, A. D., García, A., Pringle, R. M., & Palmer, T. M. (2015). Accelerated modern human–induced species losses: Entering the sixth mass extinction. *Science advances*, *1*(5), e1400253.

The oft-repeated claim that Earth's biota is entering a sixth "mass extinction" depends on clearly demonstrating that current extinction rates are far above the "background" rates prevailing between the five previous mass extinctions. Earlier estimates of extinction rates have been criticized for using assumptions that might overestimate the severity of the extinction crisis. We assess, using extremely conservative assumptions, whether human activities are causing a mass extinction. First, we use a recent estimate of a background rate of 2 mammal extinctions per 10,000 species per 100 years (that is, 2 E/MSY), which is twice as high as widely used previous estimates. We then compare this rate with the current rate of mammal and vertebrate extinctions. The latter is conservatively low because listing a species as extinct requires meeting stringent criteria. Even under our assumptions, which would tend to minimize evidence of an incipient mass extinction, the average rate of vertebrate species loss over the last century is up to 100 times higher than the background rate. Under the 2 E/MSY background rate, the number of species that have gone extinct in the last century would have taken, depending on the vertebrate taxon, between 800 and 10,000 years to disappear. These estimates reveal an exceptionally rapid loss of biodiversity over the last few centuries, indicating that a sixth mass extinction is already under way. Averting a dramatic decay of biodiversity and the subsequent loss of ecosystem services is still possible through intensified conservation efforts, but that window of opportunity is rapidly closing.

Pacifici, Michela, et al. "Species/'traits influenced their response to recent climate change." *Nature Climate Change* 7.3 (2017): 205-208.

Although it is widely accepted that future climatic change—if unabated—is likely to have major impacts on biodiversity[1,2], few studies have attempted to quantify the number of species whose populations have already been impacted by climate change[3,4]. Using a systematic review of published literature, we identified mammals and birds for which there is evidence that they have already been impacted by climate change. We modelled the relationships between observed responses and intrinsic (for example, body mass) and spatial traits (for example, temperature seasonality within the geographic range). Using this model, we estimated that 47% of terrestrial non-volant threatened mammals (out of 873 species) and 23.4% of threatened birds (out of 1,272 species) may have already been negatively impacted by climate change in at least part of their distribution. Our results suggest that populations of large numbers of threatened species are likely to be already affected by climate change, and that conservation managers, planners and policy makers must take this into account in efforts to safeguard the future of biodiversity.

Rockström, Johan, et al. "Planetary boundaries: exploring the safe operating space for humanity." *Ecology and society* 14.2 (2009).

Anthropogenic pressures on the Earth System have reached a scale where abrupt global environmental change can no longer be excluded. We propose a new approach to global sustainability in which we define planetary boundaries within which we expect that humanity can operate safely. Transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems. We have identified nine planetary boundaries and, drawing upon current scientific understanding, we propose quantifications for seven of them. These seven are climate change (CO_2 concentration in the atmosphere <350 ppm and/or a maximum change of +1 W m^{-2} in radiative forcing); ocean acidification (mean surface seawater saturation state with respect to aragonite ≥ 80% of pre-industrial levels); stratospheric ozone (<5% reduction in O_3 concentration from pre-industrial level of 290 Dobson Units); biogeochemical nitrogen (N) cycle (limit industrial and agricultural fixation of N_2 to 35 Tg N yr^{-1}) and phosphorus (P) cycle (annual P inflow to oceans not to exceed 10 times the natural background weathering of P); global freshwater use (<4000 km^3 yr^{-1} of consumptive use of runoff resources); land system change (<15% of the ice-free land surface under cropland); and the rate at which biological diversity is lost (annual rate of <10 extinctions per million species). The two additional planetary boundaries for which we have not yet been able to determine a boundary level are chemical pollution and atmospheric aerosol loading. We estimate that humanity has already transgressed three planetary boundaries: for climate change, rate of biodiversity loss, and changes to the global nitrogen cycle. Planetary boundaries are interdependent, because transgressing one may both shift the position of other boundaries or cause them to be transgressed. The social impacts of transgressing boundaries will be a function of the social–ecological resilience of the affected societies. Our proposed boundaries are rough, first estimates only, surrounded by large uncertainties and knowledge gaps. Filling these gaps will require major advancements in Earth System and resilience science. The proposed concept of “planetary boundaries” lays the groundwork for shifting our approach to governance and management, away from the essentially sectoral analyses of limits to growth aimed at minimizing negative externalities, toward the estimation of the safe space for human development. Planetary boundaries define, as it were, the boundaries of the “planetary playing field” for humanity if we want to be sure of avoiding major human-induced environmental change on a global scale.

Scheffers, Brett R., et al. "The broad footprint of climate change from genes to biomes to people." ***Science*** **354.6313 (2016): aaf7671.**

BACKGROUND

Climate change impacts have now been documented across every ecosystem on Earth, despite an average warming of only ~1°C so far. Here, we describe the full range and scale of climate change effects on global biodiversity that have been observed in natural systems. To do this, we identify a set of core ecological processes (32 in terrestrial and 31 each in marine and freshwater ecosystems) that underpin ecosystem functioning and support services to people. Of the 94 processes considered, 82% show evidence of impact from climate change in the peer-reviewed literature. Examples of observed impacts from meta-analyses and case studies go beyond well-established shifts in species ranges and changes to phenology and population dynamics to include disruptions that scale from the gene to the ecosystem.

ADVANCES

Species are undergoing evolutionary adaptation to temperature extremes, and climate change has substantial impacts on species physiology that include changes in tolerances to high temperatures, shifts in sex ratios in species with temperature-dependent sex determination, and increased metabolic costs of living in a warmer world. These physiological adjustments have observable impacts on morphology, with many species in both aquatic and terrestrial systems shrinking in body size because large surface-to-volume ratios are generally favored under warmer conditions. Other morphological changes include reductions in melanism to improve thermoregulation, and altered wing and bill length in birds.

Broader-scale responses to climate change include changes in the phenology, abundance, and distribution of species. Temperate plants are budding and flowering earlier in spring and later in autumn. Comparable adjustments have been observed in marine and freshwater fish spawning events and in the timing of seasonal migrations of animals worldwide. Changes in the abundance and age structure of populations have also been observed, with widespread evidence of range expansion in warm-adapted species and range contraction in cold-adapted species. As a by-product of species redistributions, novel community interactions have emerged. Tropical and boreal species are increasingly incorporated into temperate and polar communities, respectively, and when possible, lowland species are increasingly assimilating into mountain communities. Multiplicative impacts from gene to community levels scale up to produce ecological regime shifts, in which one ecosystem state shifts to an alternative state.

OUTLOOK

The many observed impacts of climate change at different levels of biological organization point toward an increasingly unpredictable future for humans. Reduced genetic diversity in crops, inconsistent crop yields, decreased productivity in fisheries from reduced body size, and decreased fruit yields from fewer winter chill events threaten food security. Changes in the distribution of disease vectors alongside the emergence of novel pathogens and pests are a direct threat to human health as well as to crops, timber, and livestock resources. Humanity depends on intact, functioning ecosystems for a range of goods and services. Enhanced understanding of the observed impacts of climate change on core ecological processes is an essential first step to adapting to them and mitigating their influence on biodiversity and ecosystem service provision.

Scholze, Marko, et al. "A climate-change risk analysis for world ecosystems." ***Proceedings of the National Academy of Sciences*** **103.35 (2006): 13116-13120.**

We quantify the risks of climate-induced changes in key ecosystem processes during the 21st century by forcing a dynamic global vegetation model with multiple scenarios from 16 climate models and mapping the proportions of model runs showing forest nonforest shifts or exceedance of natural variability in wildfire frequency and freshwater supply. Our analysis does not assign probabilities to scenarios or weights to models. Instead, we con- sider distribution of outcomes within three sets of model runs grouped by the amount of global warming they simulate: <2°C (including simulations in which atmospheric composition is held constant, i.e., in which the only climate change is due to green- house gases already emitted), 2–3°C, and >3°C. High risk of forest loss is shown for Eurasia, eastern China, Canada, Central America, and Amazonia, with forest extensions into the Arctic and semiarid savannas; more frequent wildfire in Amazonia, the far north, and many semiarid regions; more runoff north of 50°N and in tropical Africa and northwestern South America; and less runoff in West Africa, Central America, southern Europe, and the eastern U.S. Substantially larger areas are affected for global warming >3°C than for <2°C; some features appear only at higher warming levels. A land carbon sink of 1 Pg of C per yr is simulated for the late 20th century, but for >3°C this sink converts to a carbon source during the 21st century (implying a positive climate feedback) in 44% of cases. The risks continue increasing over the following 200 years, even with atmospheric composition held constant.

Wiens, John J. "Climate-related local extinctions are already widespread among plant and animal species." *PLoS biology* 14.12 (2016): e2001104.
Current climate change may be a major threat to global biodiversity, but the extent of species loss will depend on the details of how species respond to changing climates. For example, if most species can undergo rapid change in their climatic niches, then extinctions may be limited. Numerous studies have now documented shifts in the geographic ranges of species that were inferred to be related to climate change, especially shifts towards higher mean elevations and latitudes. Many of these studies contain valuable data on extinctions of local populations that have not yet been thoroughly explored. Specifically, overall range shifts can include range contractions at the “warm edges” of species’ ranges (i.e., lower latitudes and elevations), contractions which occur through local extinctions. Here, data on climate-related range shifts were used to test the frequency of local extinctions related to recent climate change. The results show that climate-related local extinctions have already occurred in hundreds of species, including 47% of the 976 species surveyed. This frequency of local extinctions was broadly similar across climatic zones, clades, and habitats but was significantly higher in tropical species than in temperate species (55% versus 39%), in animals than in plants (50% versus 39%), and in freshwater habitats relative to terrestrial and marine habitats (74% versus 46% versus 51%). Overall, these results suggest that local extinctions related to climate change are already widespread, even though levels of climate change so far are modest relative to those predicted in the next 100 years. These extinctions will presumably become much more prevalent as global warming increases further by roughly 2-fold to 5-fold over the coming decades.

UNEP. (2016). The Emissions Gap Report 2016: A UNEP Synthesis Report. https://europa.eu/capacity4dev/unep/document/emissions-gap-report-2016-unep-synthesis-report
Executive Summary Highlights

1. The strengthened long-term objectives of the Paris Agreement require even stronger actions than previously identified, calling for accelerated e orts pre-2020, as well as increasing the ambition of the Nationally Determined Contributions.

2. Record speed of entry into force of the Paris Agreement signals strong commitment to action. The need for urgent ac on has been reinforced by the fact that 2015 was the hottest year since modern record keeping began. Although high temperatures were exacerbated by the effect of El Niño, it is notable that 10 of the warmest years on record have occurred since 2000, and the trend continues, with the first six months of 2016 all being the warmest ever recorded.
3. The United Nations Environment (UNEP) Emissions Gap Report 2016 provides an authoritative assessment of the extent to which the current and planned national emissions reductions, as specified in the submitted Intended Nationally Determined Contributions, will contribute towards the Paris Agreement goals. It does so by providing an estimate of the additional reductions – the Gap - required by 2030 to be on a least-cost path that is likely to ensure the global temperature goals. The assessment focuses on the 2°C goal, as well as on the implications for limiting the temperature increase to 1.5°C.
4. 4. Global greenhouse gas emissions continue to increase, and while the indications are encouraging that the growth rate of global carbon dioxide emissions from fossil fuel use and industry is slowing, it is still too early to say whether this is likely to be permanent.
5. Collectively, members of the G20 are on a likely track to meet their Cancun Pledges for 2020, but these pledges do not deliver the necessary early emission reductions. Several countries will need to accelerate action to meet their Cancun Pledge by 2020. It must be underlined that, collectively, these pledges are not ambitious enough to have a better starting point in 2020 to meet the 2030 levels of global greenhouse gas emissions consistent with the longer-term goals of below 2 or 1.5°C.
6. Pathways for staying well below 2 and 1.5°C require deep emission reductions after, and preferably also before, 2020 and lower levels of emissions in 2030 than earlier assessed 2°C pathways.
7. The emissions gap for 2030 is 12 to 14 $GtCO_2e$ compared with 2°C scenarios, for 1.5°C the gap is three $GtCO_2e$ larger. Even if fully implemented, the unconditional Intended Nationally Determined Contributions are only consistent with staying below an increase in temperature of 3.2°C by 2100 and 3.0°C, if conditional Intended Nationally Determined Contributions are included.
8. Assessments of Intended Nationally Determined Contributions from individual G20 members show ambition, but also reveal that for some countries current policies are estimated to deliver greater reductions than the Intended Nationally Determined Contributions. This indicates that there might be room for strengthening the ambition of Intended Nationally Determined Contributions, noting that the analytical uncertainties are fairly large.
9. Non-state actor initiatives could likely reduce emissions in 2020 and 2030 with a few additional gigatonnes. It is di cult to assess the overlap with Intended Nationally Determined Contributions as these are o en not detailed enough. State and non-state actions can both overlap and mutually reinforce each other.

10. Ambitious action on energy efficiency becomes more urgent given that the long-term objective in the Paris Agreement is more stringent. Well-documented opportunities exist to strengthen national policies and deliver deeper reductions through more effective delivery of energy efficiency policies.

11. The Paris Agreement defines the Sustainable Development Goal (SDG) on climate change. Making the right choices in implementing all goals will be crucial to achieving the Paris Agreement objectives and the 2030 Agenda for Sustainable Development. Among the key findings of analyses to date is that the earliest impacts of climate change may undermine our ability to deliver the goals by 2030, and that failure to deliver on the climate ac on goals will have even larger implications for maintaining development progress post- 203

Climate Change and Health

"Consider this: local air pollution around the world – much of it coming straight out of exhaust pipes – kills about 6.5 million people annually. In response, many cities – including London and Oxford – countries and major automotive companies have declared an end to the internal combustion engine and are working towards emissions-free transport. They see the market is moving, because it must, and expect it to be profitable. More can follow: getting ahead of the electrification wave that is exciting investors and delivering extraordinary benefits to our air, our lungs and our hearts is in all of our interests.

I learned a long time ago that success is more likely when we take on challenges with determination and stubborn optimism. That's how parties to the United Nations climate talks regrouped after disappointing outcomes in Copenhagen and even more dire predictions from climate scientists, coming together to adopt the Paris agreement. It's why I know that we can take this critical diagnosis from climate scientists – of a climate change-fuelled public health emergency – and accelerate solutions that improve the health and wellbeing of billions."[3]

- Christiana Figueres

Chair, the Lancet Countdown advisory board

Bourque, Francois, and Ashlee Cunsolo Willox. "Climate change: the next challenge for public mental health?." *International Review of Psychiatry* 26.4 (2014): 415-422.

Climate change is increasingly recognized as one of the greatest threats to human health of the 21st century, with consequences that mental health professionals are also likely to face. While physical health impacts have been increasingly emphasized in literature and practice, recent scholarly literature indicates that climate change and related weather events and environmental changes can profoundly impact psychological well-being and mental health through both direct and indirect pathways, particularly among those with pre-existing vulnerabilities or those living in ecologically sensitive areas. Although knowledge is still limited about the connections between climate change and mental health, evidence is indicating that impacts may be felt at both the individual and community levels, with mental health outcomes ranging from psychological distress, depression and anxiety, to increased addictions and suicide rates. Drawing on examples from diverse geographical areas, this article highlights some climate-sensitive impacts that may be encountered by mental health professionals. We then suggest potential avenues for public mental health in light of current and projected changes, in order to stimulate thought, debate, and action.

[3] Climate change isn't just hurting the planet – it's a public health emergency. 2017. Retrieved from https://www.theguardian.com/commentisfree/2017/oct/31/climate-change-public-health-emergency-doctors-lancet-countdown

Carnes, Bruce A., David Staats, and Bradley J. Willcox. "Impact of climate change on elder health." *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences* 69.9 (2013): 1087-1091.
Demographers predict human life expectancy will continue to increase over the coming century. These forecasts are based on two critical assumptions: advances in medical technology will continue apace and the environment that sustains us will remain unchanged. The consensus of the scienti c community is that human activity contributes to global climate change. That change will degrade air and water quality, and global temperature could rise 11.5°F by 2100. If nothing is done to alter this climatic trajectory, humans will be confronted by a broad spectrum of radical environmental challenges. Historically, children and the elderly adults account for most of the death toll during times of severe environmental stress. This article makes an assessment from a geriatric viewpoint of the adverse health consequences that global climate change will bring to the older segments of future populations in the United States.

Ellis, Neville R., and Glenn A. Albrecht. "Climate change threats to family farmers' sense of place and mental wellbeing: A case study from the Western Australian Wheatbelt." *Social Science & Medicine* 175 (2017): 161-168.
'Sense of place' has become a central concept in the analysis of the cultural, personal and mental health risks posed by a changing climate. However, such place-related understandings of mental health and wellbeing remain largely limited to Indigenous health contexts. In this article we argue the relevance of sense of place in understanding the mental health impacts of climate change on family farmers who retain close living and working relationships to the land. We conducted a community-based qualitative case study located in the Western Australian Wheatbelt - a region that has experienced some of the most significant climate change in Australia. A three-part interview series was conducted with 22 family farmers between February 2013 and April 2014, and 15 interviews with various agricultural and mental health key informants. The research findings reveal that recently observed patterns of climate change have exacerbated farmers' worries about the weather, undermined notions of self-identity, and contributed to cumulative and chronic forms of place-based distress, culminating in heightened perceived risk of depression and suicide. The research findings highlight the tightly coupled ecosystem health-human health relationships that exist for family farmers living in regions affected by climate change, as well as the significance of farmers' place-based attachments and identities for their mental health and wellbeing.

Kjellstrom, Tord, and Anthony J. McMichael. "Climate change threats to population health and well-being: the imperative of protective solutions that will last." *Global health action* 6.1 (2013): 20816.
Background: The observational evidence of the impacts of climate conditions on human health is accumulating. A variety of direct, indirect, and systemically mediated health effects have been identified. Excessive daily heat exposures create direct effects, such as heat stroke (and possibly death), reduce work productivity, and interfere with daily household activities. Extreme weather events, including storms, floods, and droughts, create direct injury risks and follow-on outbreaks

of infectious diseases, lack of nutrition, and mental stress. Climate change will increase these direct health effects. Indirect effects include malnutrition and under-nutrition due to failing local agriculture, spread of vector-borne diseases and other infectious diseases, and mental health and other problems caused by forced migration from affected homes and workplaces. Examples of systemically mediated impacts on population health include famine, conflicts, and the consequences of large-scale adverse economic effects due to reduced human and environmental productivity. This article highlights links between climate change and non-communicable health problems, a major concern for global health beyond 2015. Discussion: Detailed regional analysis of climate conditions clearly shows increasing temperatures in many parts of the world. Climate modelling indicates that by the year 2100 the global average temperature may have increased by 3 48C unless fundamental reductions in current global trends for greenhouse gas emissions are achieved. Given other unforeseeable environmental, social, demographic, and geopolitical changes that may occur in a plus-4-degree world, that scenario may comprise a largely uninhabitable world for millions of people and great social and military tensions. Conclusion: It is imperative that we identify actions and strategies that are effective in reducing these increasingly likely threats to health and well-being. The fundamental preventive strategy is, of course, climate change mitigation by significantly reducing global greenhouse gas emissions, especially long-acting carbon dioxide (CO_2), and by increasing the uptake of CO_2 at the earth's surface. This involves urgent shifts in energy production from fossil fuels to renewable energy sources, energy conservation in building design and urban planning, and reduced waste of energy for transport, building heating/cooling, and agriculture. It would also involve shifts in agricultural production and food systems to reduce energy and water use particularly in meat production. There is also potential for prevention via mitigation, adaptation, or resilience building actions, but for the large populations in tropical countries, mitigation of climate change is required to achieve health protection solutions that will last.

Landrigan, Philip J., et al. "The Lancet Commission on pollution and health." ***The Lancet*** **(2017).**
Pollution is the largest environmental cause of disease and premature death in the world today. Diseases caused by pollution were responsible for an estimated 9 million premature deaths in 2015—16% of all deaths worldwide—three times more deaths than from AIDS, tuberculosis, and malaria combined and 15 times more than from all wars and other forms of violence. In the most severely affected countries, pollution-related disease is responsible for more than one death in four.

Pollution disproportionately kills the poor and the vulnerable. Nearly 92% of pollution-related deaths occur in low-income and middle-income countries and, in countries at every income level, disease caused by pollution is most prevalent among minorities and the marginalised. Children are at high risk of pollution-related disease and even extremely low-dose exposures to pollutants during windows of vulnerability in utero and in early infancy can result in disease, disability, and death in childhood and across their lifespan.

Despite its substantial effects on human health, the economy, and the environment, pollution has been neglected, especially in low-income and middle-income countries, and the health effects of pollution are under-estimated in calculations of the global burden of disease. Pollution in low-income and middle-income countries that is caused by industrial emissions, vehicular exhaust, and toxic chemicals has particularly been overlooked in both the international development and the global health agendas. Although more than 70% of the diseases caused by pollution are non-communicable diseases, inter-ventions against pollution are barely mentioned in the Global Action Plan for the Prevention and Control of Non-Communicable Diseases. Pollution is costly. Pollution-related diseases cause productivity losses that reduce gross domestic product (GDP) in low-income to middle-income countries by up to 2% per year. Pollution-related disease also results in health-care costs that are responsible for 1·7% of annual health spending in high-income countries and for up to 7% of health spending in middle-income countries that are heavily polluted and rapidly developing. Welfare losses due to pollution are estimated to amount to US$4·6 trillion per year: 6·2% of global economic output. The costs attributed to pollution-related disease will probably increase as additional associations between pollution and disease are identified.

Pollution endangers planetary health, destroys eco-systems, and is intimately linked to global climate change. Fuel combustion—fossil fuel combustion in high-income and middle-income countries and burning of biomass in low-income countries—accounts for 85% of airborne particulate pollution and for almost all pollution by oxides of sulphur and nitrogen. Fuel combustion is also a major source of the greenhouse gases and short-lived climate pollutants that drive climate change. Key emitters of carbon dioxide, such as electricity-generating plants, chemical manufacturing facilities, mining operations, deforestation, and petroleum-powered vehicles, are also major sources of pollution. Coal is the world's most polluting fossil fuel, and coal combustion is an important cause of both pollution and climate change.

McMichael, Anthony J., Rosalie E. Woodruff, and Simon Hales. "Climate change and human health: present and future risks." ***The Lancet*** **367.9513 (2006): 859-869.**
There is near unanimous scientific consensus that greenhouse gas emissions generated by human activity will change Earth's climate. The recent (globally averaged) warming by 0·5°C is partly attributable to such anthropogenic emissions. Climate change will affect human health in many ways—mostly adversely. Here, we summarise the epidemiological evidence of how climate variations and trends affect various health outcomes. We assess the little evidence there is that recent global warming has already affected some health outcomes. We review the published estimates of future health effects of climate change over coming decades. Research so far has mostly focused on thermal stress, extreme weather events, and infectious diseases, with some attention to estimates of future regional food yields and hunger prevalence. An emerging broader approach addresses a wider spectrum of health risks due to the social, demographic, and economic disruptions of climate change. Evidence and anticipation of adverse health effects will strengthen the case for pre-emptive policies, and will also guide priorities for planned adaptive strategies.

Schmidhuber, Josef, and Francesco N. Tubiello. "Global food security under climate change." *Proceedings of the National Academy of Sciences* 104.50 (2007): 19703-19708.
This article reviews the potential impacts of climate change on food security. It is found that of the four main elements of food security, i.e., availability, stability, utilization, and access, only the first is routinely addressed in simulation studies. To this end, published results indicate that the impacts of climate change are significant, however, with a wide projected range (between 5 million and 170 million additional people at risk of hunger by 2080) strongly depending on assumed socio-economic development. The likely impacts of climate change on the other important dimensions of food security are discussed qualitatively, indicating the potential for further negative impacts beyond those currently assessed with models. Finally, strengths and weaknesses of current assessment studies are discussed, suggesting improvements and proposing avenues for new analyses.

Shuman, Emily K. "Global climate change and infectious diseases." *New England Journal of Medicine* 362.12 (2010): 1061-1063.
The 2009 United Nations Climate Change Conference in Copenhagen ended on December 18 without passage of a binding resolution for tack- ling global climate change. With the debate over U.S. health care reform raging, this event went largely unnoticed by the U.S. health care community. However, climate change will have enormous implications for human health, especially for the burden of vectorborne and waterborne infectious diseases.

Tschakert, Petra, Raymond Tutu, and Anna Alcaro. "Embodied experiences of environmental and climatic changes in landscapes of everyday life in Ghana." *Emotion, Space and Society* 7 (2013): 13-25.
Science and policy attention to global environmental and climatic change has been growing substantially. Yet, the psychological and emotional distress and pain triggered by these transformations have been largely ignored, particularly among poor and marginalized populations whose livelihoods depend on the living land. Building upon key geographical concepts of landscapes and place and embodied engage- ments within, we focus on environmentally-induced distress and loss of belonging (‘solastalgia’) in the coupled context of environmental and climatic changes and internal migration in Ghana. We assess the differential emotional experiences and memory among those who migrate from deteriorating environ- ments in the North to urban slums in the capital Accra and those who stay behind in these altered homes. We use participatory mapping and ’walking journeys’ in northern regions to examine understandings of landscapes of everyday life and identify places that induce solastalgia. Results illustrate that the combination of withered crops, drying up of wells, loss of beauty, and deteriorating social networks trigger strong emotional responses, in particular feelings of sadness. We conclude that these emotional responses are expressions of solastalgia in what we call “hollow homes” where place and self of agrarian livelihoods undergo both figurative and literal desiccation.

Watts, Nick, et al. "Health and climate change: policy responses to protect public health." ***The Lancet*** **386.10006 (2015): 1861-1914.**

Executive summary

The effects of climate change are being felt today, and future projections represent an unacceptably high and potentially catastrophic risk to human health The implications of climate change for a global population of 9 billion people threatens to undermine the last half century of gains in development and global health. The direct effects of climate change include increased heat stress, floods, drought, and increased frequency of intense storms, with the indirect threatening population health through adverse changes in air pollution, the spread of disease vectors, food insecurity and under-nutrition, displacement, and mental ill health.
Keeping the global average temperature rise to less than 2°C to avoid the risk of potentially catastrophic climate change impacts requires total anthropogenic carbon dioxide (CO_2) emissions to be kept below 2900 billion tonnes ($GtCO_2$) by the end of the century. As of 2011, total emissions since 1870 were a little over half of this, with current trends expected to exceed 2900 $GtCO_2$ in the next 15–30 years. High-end emissions projection scenarios show global average warming of 2·6–4·8°C by the end of the century, with all their regional amplification and attendant impacts.

Tackling climate change could be the greatest global health opportunity of the 21st century. Given the potential of climate change to reverse the health gains from economic development, and the health co-benefits that accrue from actions for a sustainable economy, tackling climate change could be the greatest global health opportunity of this century. Many mitigation and adaptation responses to climate change are “no-regret” options, which lead to direct reductions in the burden of ill-health, enhance community resilience, alleviate poverty, and address global inequity. Benefits are realised by ensuring that countries are unconstrained by climate change, enabling them to achieve better health and wellbeing for their populations. These strategies will also reduce pressures on national health budgets, delivering potentially large cost savings, and enable investments in stronger, more resilient health systems.

Achieving a decarbonised global economy and securing the public health benefits it offers is no longer primarily a technical or economic question—it is now a political one. Major technical advances have made buildings and vehicles more efficient and renewable energy sources far more cost effective. Globally, there is plentiful financial resource available, however much of it is still being directed towards the fossil-fuel industry. Bold political commitment can ensure that the technical expertise, technology, and finance to prevent further significant climate change is readily available, and is not a barrier to action.

The health community has a vital part to play in accelerating progress to tackle climate change. Health professionals have worked to protect against health threats, such as tobacco, HIV/AIDS, and polio, and have often confronted powerful entrenched interests in doing so. Likewise, they must be leaders in responding to the health threat of climate change. A public health perspective has the potential to unite all actors behind a common cause—the health and wellbeing of our families, communities, and countries. These concepts are far more tangible and visceral than tonnes of atmospheric CO_2, and are understood and prioritised across all populations irrespective of culture or development status. Reducing inequities within and between countries is crucial to promoting climate change resilience and improving global health. Neither can be delivered without accompanying sustainable development that addresses key health determinants: access to safe water and clean air, food security, strong and accessible health systems, and reductions in social and economic inequity. Any prioritisation in global health must therefore place sustainable development and climate change front and centre.

Whitmee, Sarah, et al. "Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health." *The Lancet* 386.10007 (2015): 1973-2028.

Key messages

1. The concept of planetary health is based on the understanding that human health and human civilisation depend on flourishing natural systems and the wise stewardship of those natural systems. However, natural systems are being degraded to an extent unprecedented in human history.
2. Environmental threats to human health and human civilisation will be characterised by surprise and uncertainty. Our societies face clear and potent dangers that require urgent and transformative actions to protect present and future generations.
3. The present systems of governance and organisation of human knowledge are inadequate to address the threats to planetary health. We call for improved governance to aid the integration of social, economic, and environmental policies and for the creation, synthesis, and application of interdisciplinary knowledge to strengthen planetary health.
4. Solutions lie within reach and should be based on the redefinition of prosperity to focus on the enhancement of quality of life and delivery of improved health for all, together with respect for the integrity of natural systems. This endeavour will necessitate that societies address the drivers of environmental change by promoting sustainable and equitable patterns of consumption, reducing population growth, and harnessing the power of technology for change.

Energy and Sustainability Transitions

"Two major economic factors lie at the heart of India's move away from coal. The first is that the country's growth rate, while faster than that of most major economies, slipped to 6.1 percent for the most recent quarter, down from 7 percent in the previous quarter. And much of that growth has come in service industries rather than in power-hungry manufacturing.

Equally important is the startling drop in the price of renewable energy sources. Many energy experts say renewables are poised to become a less expensive alternative to coal within the next decade.

"The train has left the station. Mr. Trump has come too late" to slow the transition to renewable energy, said Ajay Mathur, director general of the Energy Resources Institute, a New Delhi policy center closely associated with the government. "By the time the coal-fired plants come up to full capacity because of increasing demand, the price of renewables will be lower than the price of coal."'"[4]

- Geeta Anand
The New York Times

Alemán-Nava, Gibrán S., et al. "Renewable energy research progress in Mexico: A review." *Renewable and Sustainable Energy Reviews* 32 (2014): 140-153.

Mexico ranks 9th in the world in crude oil reserves, 4th in natural gas reserves in America and it is also highly rich in renewable energy sources (solar, wind, biomasss, hydropower and geothermal). However, the potential of this type of energy has not been fully exploited. Hydropower is the renewable energy source with the highest installed capacity within the country (11,603 MW), while geothermal power capacity (958 MW) makes Mexico to be ranked 4th in the use of this energy worldwide. Wind energy potential is concentrated in five different zones, mainly in the state of Oaxaca, and solar energy has a high potential due to Mexico^{0}s ideal location in the so called Solar Belt. Biomass energy has the highest potential (2635 to 3771 PJ/year) and has been the subject of the highest number of research publications in the country during the last 30 years (1982–2012). Universidad Nacional Autonoma de Mexico has led research publications in hydropower, wind, solar and biomass energy and Instituto de Investigaciones Electricas in geothermal energy during this period. According to the General Law for Climate Change the country has set the goal of generating 35% of its energy needs from renewable sources by 2024. This paper presents an overview of the renewable energy options available in Mexico, current status, main positive results to date and future potential. It also analyses barriers hindering improvements and proposes pertinent solutions.

[4] India, Once a Coal Goliath, Is Fast Turning Green. 2017. Retrieved from https://www.nytimes.com/2017/06/02/world/asia/india-coal-green-energy-climate.html

Bai, Xuemei, et al. "Plausible and desirable futures in the Anthropocene: a new research agenda." *Global Environmental Change* 39 (2016): 351-362.

While the concept of the Anthropocene reflects the past and present nature, scale and magnitude of human impacts on the Earth System, its true significance lies in how it can be used to guide attitudes, choices, policies and actions that influence the future. Yet, to date much of the research on the Anthropocene has focused on interpreting past and present changes, while saying little about the future. Likewise, many futures studies have been insufficiently rooted in an understanding of past changes, in particular the long-term co-evolution of bio-physical and human systems. The Anthropocene perspective is one that encapsulates a world of intertwined drivers, complex dynamic structures, emergent phenomena and unintended consequences, manifest across different scales and within interlinked biophysical constraints and social conditions. In this paper we discuss the changing role of science and the theoretical, methodological and analytical challenges in considering futures of the Anthropocene. We present three broad groups of research questions on: (1) societal goals for the future; (2) major trends and dynamics that might favor or hinder them; (3) and factors that might propel or impede transformations towards desirable futures. Tackling these questions requires the development of novel approaches integrating natural and social sciences as well as the humanities beyond what is current today. We present three examples, one from each group of questions, illustrating how science might contribute to the identification of desirable and plausible futures and pave the way for transformations towards them. We argue that it is time for debates on the sustainability of the Anthropocene to focus on opportunities for realizing desirable and plausible futures.

Green, Fergus, and Nicholas Stern. "China's changing economy: implications for its carbon dioxide emissions." *Climate Policy* 17.4 (2017): 423-442.

As China's government unveils the country's 13th Five Year Plan for economic development (2016 – 2020), this article takes stock of recent changes in China's economy and energy system since the turn of the century, and looks ahead to the likely trajectory of China's emissions over the next decade. It is now clear that the period 2000–2013 was a distinct and exceptional phase in China's developmental history, during which the very high levels of GHGs emitted were linked closely with the energy-intensive, heavy industry-based growth model pursued at that time. China is currently undergoing another major structural transformation – towards a new development model focused on achieving better-quality growth that is more sustainable and inclusive – and it is also grappling with the economic challenges associated with this transition. Data from 2014 and the first three quarters of 2015 illustrate the extent of these changes. Based on analysis of this data in light of the underlying changes occurring in China's economy and policy, this article provides an updated forecast of the Kaya components of energy CO_2 emissions (GDP, energy/ GDP and CO_2/energy) over the next decade to 2025. It concludes that China's CO_2 emissions from energy, if they grow at all, are likely to grow at a much slower rate than under the old economic model and are likely to peak at some point in the decade before 2025.

Hess, David J. "Sustainability transitions: A political coalition perspective." *Research Policy* 43.2 (2014): 278-283.

In the case of technology transitions to low-carbon sources of energy, there is growing evidence that even in countries with a strong political consensus in favor of a transition, the pace has been slow in comparison with the need to reduce greenhouse gases. One factor that affects the slowness of the transition is political resistance from the incumbent industrial regime. Using data on the mobilization of resistance from the fossil-fuel industry in the United States, the study builds on the growing literature on the political dimensions of sustainability transitions by drawing attention to the role of incumbent regime coalitions, grassroots coalitions in support of green transition policies, and countervailing industrial power. Case studies of political coalitions for ballot propositions in the U.S. are used to show how countervailing industrial power, especially from the technology and financial sector, can tip the balance of electoral spending in favor of grassroots organizations.

McGlade, Christophe, and Paul Ekins. "The geographical distribution of fossil fuels unused when limiting global warming to 2 [deg] C." *Nature* 517.7533 (2015): 187-190.

Policy makers have generally agreed that the average global temperature rise caused by greenhouse gas emissions should not exceed 2 6C above the average global temperature of pre-industrial times[1]. It has been estimated that to have at least a 50 per cent chance of keeping warming below 2 6C throughout the twenty-first century, the cumulative carbon emissions between 2011 and 2050 need to be limited to around 1,100 gigatonnes of carbon dioxide (Gt CO_2)[2,3]. However, the greenhouse gas emissions contained in present estimates of global fossil fuel reserves are around three times higher than this[2,4], and so the unabated use of all current fossil fuel reserves is incompatible with a warming limit of 2 6C. Here we use a single integrated assessment model that contains estimates of the quantities, locations and nature of the world's oil, gas and coal reserves and resources, and which is shown to be consistent with a wide variety of modelling approaches with different assumptions[5], to explore the implications of this emissions limit for fossil fuel production in different regions. Our results suggest that, globally, a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2 6C. We show that development of resources in the Arctic and any increase in unconventional oil production are incommensurate with efforts to limit average global warming to 2 6C. Our results show that policy makers' instincts to exploit rapidly and completely their territorial fossil fuels are, in aggregate, inconsistent with their commitments to this temperature limit. Implementation of this policy commitment would also render unnecessary continued substantial expenditure on fossil fuel exploration, because any new discoveries could not lead to increased aggregate production.

McGlade, Christophe, and Paul Ekins. "Un-burnable oil: an examination of oil resource utilisation in a decarbonised energy system." *Energy Policy* 64 (2014): 102-112.

This paper examines the volumes of oil that can and cannot be used up to 2035 during the transition to a low-carbon global energy system using the global energy systems model, TIAM-UCL and the 'Bottom up Economic and Geological Oil field production model' (BUEGO). Globally in a scenario allowing the widespread adoption of carbon capture and storage (CCS) nearly 500 billion barrels of existing 2P oil reserves must remain unused by 2035. In a scenario where CCS is unavailable this increases to around 600 billion barrels. Besides reserves, arctic oil and light tight oil play only minor roles in a scenario with CCS and essentially no role when CCS is not available. On a global scale, 40% of those resources yet to be found in deepwater regions must remain undeveloped, rising to 55% if CCS cannot be deployed. The widespread development of unconventional oil resources is also shown to be incompatible with a decarbonised energy system even with a total and rapid decarbonisation of energetic inputs. The work thus demonstrates the extent to which current energy policies encouraging the unabated exploration for, and exploitation of, all oil resources are incommensurate with the achievement of a low-carbon energy system.

Meinshausen, Malte, et al. "Greenhouse-gas emission targets for limiting global warming to 2 C." *Nature* 458.7242 (2009): 1158-1162.
More than 100 countries have adopted a global warming limit of 2 °C or below (relative to pre-industrial levels) as a guiding principle for mitigation efforts to reduce climate change risks, impacts and damages[1,2]. However, the greenhouse gas (GHG) emissions corresponding to a specified maximum warming are poorly known owing to uncertainties in the carbon cycle and the climate response. Here we provide a comprehensive probabilistic analysis aimed at quantifying GHG emission budgets for the 2000–50 period that would limit warming throughout the twenty-first century to below 2 °C, based on a combination of published distributions of climate system properties and observational constraints. We show that, for the chosen class of emission scenarios, both cumulative emissions up to 2050 and emission levels in 2050 are robust indicators of the probability that twenty-first century warming will not exceed 2 °C relative to pre-industrial temperatures. Limiting cumulative CO_2 emissions over 2000–50 to 1,000 Gt CO_2 yields a 25% probability of warming exceeding 2 °C—and a limit of 1,440 Gt CO_2 yields a 50% probability—given a representative estimate of the distribution of climate system properties. As known 2000–06 CO_2 emissions[3] were ~234 Gt CO_2, less than half the proven economically recoverable oil, gas and coal reserves[4,5,6] can still be emitted up to 2050 to achieve such a goal. Recent G8 Communiqués[7] envisage halved global GHG emissions by 2050, for which we estimate a 12–45% probability of exceeding 2 °C—assuming 1990 as emission base year and a range of published climate sensitivity distributions. Emissions levels in 2020 are a less robust indicator, but for the scenarios considered, the probability of exceeding 2 °C rises to 53–87% if global GHG emissions are still more than 25% above 2000 levels in 2020.

Millar, Richard J., et al. "Emission budgets and pathways consistent with limiting warming to 1.5 [thinsp][deg] C." *Nature Geoscience* 10.10 (2017): 741-747.
We show that limiting cumulative post-2015 CO_2 emissions to about 200 GtC would limit post-2015 warming to less than 0.6 °C in 66% of Earth system model members of the CMIP5

ensemble with no mitigation of other climate drivers, increasing to 240 GtC with ambitious non-CO_2 mitigation. We combine a simple climate–carbon-cycle model with estimated ranges for key climate system properties from the IPCC Fifth Assessment Report. Assuming emissions peak and decline to below current levels by 2030, and continue thereafter on a much steeper decline, which would be historically unprecedented but consistent with a standard ambitious mitigation scenario (RCP2.6), results in a likely range of peak warming of 1.2–2.0 °C above the mid-nineteenth century. If CO_2 emissions are continuously adjusted over time to limit 2100 warming to 1.5 °C, with ambitious non-CO_2 mitigation, net future cumulative CO_2 emissions are unlikely to prove less than 250 GtC and unlikely greater than 540 GtC. Hence, limiting warming to 1.5 °C is not yet a geophysical impossibility, but is likely to require delivery on strengthened pledges for 2030 followed by challengingly deep and rapid mitigation. Strengthening near-term emissions reductions would hedge against a high climate response or subsequent reduction rates proving economically, technically or politically unfeasible.

Parthan, Binu, et al. "Lessons for low-carbon energy transition: Experience from the Renewable Energy and Energy Efficiency Partnership (REEEP)." ***Energy for Sustainable Development*** **14.2 (2010): 83-93.**
The article is intended as a report on the performance of the Renewable Energy and Energy Efficiency Partnership (REEEP) in delivering a global low-carbon energy market facilitation programme. The article documents REEEP's 5 years of experience in energy efficiency and renewable energy programme delivery, as well as market development in developing countries; it describes the delivery mechanisms, process, and governance before proceeding to analyse the REEEP portfolio. The article then assesses REEEP's experience in delivering a capacity building initiative, identifying lessons in the areas of programme management, carbon finance, financing, business models, energy in buildings, rural energy, energy regulation, and energy policy. The article demonstrates that REEEP programmes offer a number of lessons for policy makers and managers involved in climate change and development issues in developing countries. It also shows that REEEP is positioned to scale-up its activities and respond to requests that are currently constrained by limited resources. The article concludes by recommending the scaling up of REEEP's operations.

Qi, Ye, et al. "China's post-coal growth." ***Nature Geoscience*** **(2016).**
Slowing GDP growth, a structural shift away from heavy industry, and more proactive policies on air pollution and clean energy have caused China's coal use to peak. It seems that economic growth has decoupled from growth in coal consumption.

Santos-Alamillos, Francisco J., et al. "Assessing the economic feasibility of the gradual decarbonization of a large electric power system." ***Journal of Cleaner Production*** **147 (2017): 130-141.**

The decarbonization of power systems is among the primary actions to fight air pollution and climate change. In this study, we evaluate the costs of a gradual transition towards a new power system in which the oldest coal plants are replaced with low-carbon power plants. We developed the Wind Energy Integration Cost Advisor Model (WEICAM) to analyze different strategies for this energy transition and determine the most cost-effective roadmap, with and without externalities. The test case is the PJM Interconnection, one of the power systems in the United States with the largest fraction of coal. Different strategies to replace coal plants are evaluated: 1) installing only new, high-efficiency, natural-gas combined-cycle plants (control case), 2) installing new wind farms in combination with natural-gas combined-cycle plants used as spinning reserves (wind case), and 3) same as the wind case but boosting up the production of existing baseload plants that work with a capacity factor between 50% and 60%–80% before installing new wind farms. All three strategies have similar costs (~54 $/MWh), but the latter is slightly more cost-effective, with a total of 19 GW of coal capacity decommissioned and an increase in the levelized cost of electricity from 49.1 to 53.6 $/MWh (without externalities). In addition, selecting the windiest sites – even far away from the PJM region – is cheaper than selecting local but less windy sites. When externalities due to human health and environmental pollution are accounted for, the two wind-based strategies become the most advantageous, reducing the levelized cost below 104 $/MWh from the initial 110 $/MWh. We conclude that adding new wind farms from the windiest locations, accompanied by a better management of existing plants and a small addition of new natural-gas reserve capacity, is the most economic and the most environmentally responsible pathway to replace retiring coal-fired power plants in PJM.

Westley, Frances, et al. "Tipping toward sustainability: emerging pathways of transformation." ***AMBIO: A Journal of the Human Environment*** **40.7 (2011): 762-780.**
This article explores the links between agency, institutions, and innovation in navigating shifts and large-scale transformations toward global sustainability. Our central question is whether social and technical innovations can reverse the trends that are challenging critical thresholds and creating tipping points in the earth system, and if not, what conditions are necessary to escape the current lock-in. Large-scale transformations in information technology, nano- and biotechnology, and new energy systems have the potential to significantly improve our lives; but if, in framing them, our globalized society fails to consider the capacity of the biosphere, there is a risk that unsustainable development pathways may be reinforced. Current institutional arrangements, including the lack of incentives for the private sector to innovate for sustainability, and the lags inherent in the path dependent nature of innovation, contribute to lock-in, as does our incapacity to easily grasp the interactions implicit in complex problems, referred to here as the ingenuity gap. Nonetheless, promising social and technical innovations with potential to change unsustainable trajectories need to be nurtured and connected to broad institutional resources and responses. In parallel, institutional entrepreneurs can work to reduce the resilience of dominant institutional systems and position viable shadow alternatives and niche regimes.

Yuan, Xueliang, and Jian Zuo. "Transition to low carbon energy policies in China—from the Five-Year Plan perspective." *Energy Policy* 39.6 (2011): 3855-3859.

Energy policy plays a critical role not only in the energy development, but also in the social and environmental aspects of a nation. Five-Year Plan for National Economic and Social Development is one of the most important government plans, which documents the national strategy during that period. This study presents a critical review of 12 Five-Year Plans that have been released by the Chinese central government in last 58 years. In particular, the recently released Twelfth Five-Year Plan is reviewed. The results clearly show a pattern of increasingly level of attention of Chinese government to energy efficiency improvement, air pollutant emission reduction, new and renewable energy development, carbon dioxide emission and climate change.

Sustainable Finance

"Companies selling fossil fuels are facing their Netflix moment, as cheap solar panels and electric vehicles are poised to do to coal-fired power stations and gas stations what online streaming did to Blockbuster.

This warning comes not from Greenpeace, but from the international Task Force on Climate-related Financial Disclosure established by Mark Carney, former Governor of the Bank of Canada and present Governor of the Bank of England. The Task Force was set up as part of an initiative by the G20 finance ministers and central bankers to avoid another financial meltdown like the 2008 subprime mortgage crisis. They chose to focus on climate-related risks after Carney warned in 2015 that climate change could become a "defining issue for financial stability.""[5]

- Keith Stewart
National Observer

Aras, Guler, and David Crowther. "Sustaining business excellence." *Total Quality Management* 21.5 (2010): 565-576.
Many concepts have appeared fashionable as a process of business management and the latest of these is connected to sustainability. Often these concepts are merely refinements of other concepts but are presented as the answer to managing a business. We argue in this paper that these concepts do not replace earlier concepts. Instead, we argue, that the way to manage a business for excellence and sustainable competitive advantage is to focus on the four key areas of profitability, sustainability, reputation and governance.

Bello, Zakri Y. "Socially responsible investing and portfolio diversification." *Journal of Financial Research* 28.1 (2005): 41-57.
I use a sample of socially responsible stock mutual funds matched to randomly selected conventional funds of similar net assets to investigate differences in characteristics of assets held, portfolio diversification, and variable effects of diversification on investment performance. I find that socially responsible funds do not differ significantly from conventional funds in terms of any of these attributes. Moreover, the effect of diversification on investment performance is not different between the two groups. Both groups underperform the Domini 400 Social Index and S&P 500 during the study period.

[5] To protect pensions, companies should be required to come clean on climate risk. 2017. Retrieved from https://www.nationalobserver.com/2017/11/27/opinion/protect-pensions-companies-should-be-required-come-clean-climate-risk

Bond, Kingsmill. Revolution not evolution: Marginal change and the transformation of the fossil fuel industry. Sustainable Finance Programme. Smith School of Enterprise and the Environment. University of Oxford. Discussion Paper. February 2017. Retrieved from http://www.smithschool.ox.ac.uk/research/sustainable-finance/publications/Revolution-not-evolution-SFP-Discussion-Paper-February-2017.pdf.

Key Findings

Revolutionary change is about to transform the fossil fuel industry as policy-driven change moves to market-led change. Companies and investors need to abandon the false hope of slow evolutionary adjustment.

- The hope for evolution. The orthodox view on energy transitions argues that systemic change will take generations, implying that the energy incumbency has nothing to fear from ongoing changes to energy markets.
- Marginal change is key. However, what matters for companies and financial markets is marginal change, which is two orders of magnitude smaller than systemic change.
- Change is upon us. In 2015, solar and wind energy sources supplied only 2% of total energy but 33% of marginal energy supply. Non-fossils as a whole supplied 51% of marginal supply.
- Growth continues apace. The cost of electricity from solar and wind continues to fall rapidly, challenging fossil fuels in ever more locations. And falling costs drives annual growth of around 20%.
- The emerging market leapfrog. Led by China, the emerging markets are finding a different path to development fuelled by renewables not fossil fuels.
- Peak fossil fuels by 2020. Assuming global energy demand growth of 1% and solar and wind supply growth of 20%, fossil fuel demand is likely to peak by 2020.
- Why is marginal change happening so fast? Renewables are not the same as fossil fuels; policymakers want to reduce fossil fuel consumption; and the world has moved on from the time of the last big energy transition.
- Expect revolution. Once fossil fuel demand starts to fall, incumbent producers will face disruptive change as competition intensifies between fuels, prices fall, and assets become stranded.
- The process has already started. Investors do not need to look far to see the disruptive impact of marginal change. The coal industry saw widespread bankruptcies when demand was just 2% off its all- time peak, and the European electricity sector is undergoing radical restructuring when demand is 5% below its 2007 peak.
- History is replete with examples of the power of marginal change. Even when new energy technologies have been small (2-3% of supply) they have in the past caused lower volumes and prices for the incumbents. Examples from the UK include the shift from steam to electricity in the power sector after 1907 or the shift from gas to electricity in the lighting sector after 1914.
- Investors can’t wait for systemic change. By the time the market share of new technologies had reached 25% in the UK energy transformations of the twentieth century, demand for the old technology had already been falling for 25 years.

Caldecott, B., Tilbury, J., & Carey, C. (2014). Stranded assets and scenarios. Smith School of Enterprise and the Environment, University of Oxford. Retrieved from http://www.smithschool.ox.ac.uk/research/sustainable-finance/publications/Stranded-Assets-and-Scenarios-Discussion-Paper.pdf
Environment-related factors are already stranding assets in different sectors of the economy. This trend looks to be accelerating, which could represent a major discontinuity able to profoundly alter asset values across the global economy. But such stranded asset risks often manifest themselves indirectly and are difficult to predict.

For example, water scarcity in China threatens coal-fired power generation, which will change coal demand and affect global coal prices; the shale gas revolution in the US has put downward pressure on coal prices in Europe, stranding new high-efficiency gas plants; and the fossil fuel divestment campaign threatens to erode the social licence of some targeted companies and could increase their cost of capital. Scenario analysis is one tool that can help incorporate this kind of uncertainty into decision-making. Rather than trying to predict the future precisely, scenario analysis attempts to delimit the range of possible futures. In doing so it can allow managers and investors to increase the resilience of their assets by making them better prepared for inherently hard to predict events.

Preparing for multiple possible futures is particularly important for understanding and managing the risks that can result in stranded assets. Many of the environment-related factors that could strand assets involve significant uncertainties, both in the magnitude and direction (e.g. more or less rainfall) of their impacts. They are also typically interacting and reinforcing; preparing for either a change in government policy or falling technology costs will not be adequate preparation for a combination of both occurring. Scenario analysis can help to deal with these issues by providing a framework for understanding the implications of a range of different combinations of potential outcome.

The aims of this high-level discussion paper are three fold: first, to propose a general type of scenarios that would be most useful for the management of stranded asset risks; second, to review existing scenarios to determine trends and gaps in the literature; and third, to encourage organisations involved or interested in stranded assets to consider how best to proceed with scenarios in the future.

Hsiang, Solomon, et al. "Estimating economic damage from climate change in the United States." ***Science*** **356.6345 (2017): 1362-1369.**
Estimates of climate change damage are central to the design of climate policies. Here, we develop a flexible architecture for computing damages that integrates climate science, econometric analyses, and process models. We use this approach to construct spatially explicit, probabilistic, and empirically derived estimates of economic damage in the United States from climate change. The combined value of market and nonmarket damage across analyzed sectors—agriculture, crime, coastal storms, energy, human mortality, and labor—increases

quadratically in global mean temperature, costing roughly 1.2% of gross domestic product per +1°C on average. Importantly, risk is distributed unequally across locations, generating a large transfer of value northward and westward that increases economic inequality. By the late 21st century, the poorest third of counties are projected to experience damages between 2 and 20% of county income (90% chance) under business-as-usual emissions (Representative Concentration Pathway 8.5).

Lo, Shih-Fang, and Her-Jiun Sheu. "Is corporate sustainability a value-increasing strategy for business?." *Corporate Governance: An International Review* 15.2 (2007): 345-358.
A new movement reconciling corporate sustainability and investment is gaining world-wide attention. Whether corporate sustainability has an impact on market value is examined using large US non-financial firms from 1999 to 2002 in this paper. Taking Tobin's *q* as the proxy for firm value, a significantly positive relation between corporate sustainability and its market value is found. We also find a strong interaction effect between corporate sustainability and sales growth on firm value. Moreover, there is evidence to support that being sustainable causes a firm to increase its value. This indicates that companies with remarkable sustainable development strategies are more likely to be rewarded by investors with a higher valuation in the financial markets.

Orlitzky, Marc, Frank L. Schmidt, and Sara L. Rynes. "Corporate social and financial performance: A meta-analysis." *Organization studies* 24.3 (2003): 403-441.
Most theorizing on the relationship between corporate social/environmental performance (CSP) and corporate financial performance (CFP) assumes that the current evidence is too fractured or too variable to draw any generalizable conclusions. With this integrative, quantitative study, we intend to show that the mainstream claim that we have little generalizable knowledge about CSP and CFP is built on shaky grounds. Providing a methodologically more rigorous review than previous efforts, we conduct a meta-analysis of 52 studies (which represent the population of prior quantitative inquiry) yielding a total sample size of 33,878 observations. The meta-analytic findings suggest that corporate virtue in the form of social responsibility and, to a lesser extent, environmental responsibility is likely to pay off, although the operationalizations of CSP and CFP also moderate the positive association. For example, CSP appears to be more highly correlated with accounting-based measures of CFP than with market-based indicators, and CSP reputation indices are more highly correlated with CFP than are other indicators of CSP. This meta-analysis establishes a greater degree of certainty with respect to the CSP–CFP relationship than is currently assumed to exist by many business scholars.

Rahimnejad, Mostafa, et al. "Microbial fuel cell as new technology for bioelectricity generation: a review." *Alexandria Engineering Journal* 54.3 (2015): 745-756.
Recently, great attentions have been paid to microbial fuel cells (MFCs) due to their mild operating conditions and using variety of biodegradable substrates as fuel. The traditional MFC consisted of anode and cathode compartments but there are single chamber MFCs. Microorganisms actively catabolize substrate, and bioelectricities are generated. MFCs could be

utilized as power generator in small devices such as biosensor. Besides the advantages of this technology, it still faces practical barriers such as low power and current density. In the present article different parts of MFC such as anode, cathode and membrane have been reviewed and to overcome the practical challenges in this field some practical options have been suggested. Also, this research review demonstrates the improvement of MFCs with summarization of their advantageous and possible applications in future application. Also, Different key factors affecting bioelectricity generation on MFCs were investigated and these key parameters are fully discussed.

Rubin, Jeff. "Divestment Increasingly Motivated by Economic Concerns." CIGI Papers No. 112 — October 2016. Retrieved from https://www.cigionline.org/sites/default/files/documents/CIGI%20Paper%20no.112web.pdf.
Executive Summary
Emissions reduction targets pledged recently by 174 countries, including Canada, require urgent actions whose impact on global fuel demand seem incompatible with a sustained and strong recovery in fuel prices that the oil sands and other high-cost fossil fuels require to remain economically viable. Federal and provincial governments need to ensure that the nancial risks posed by climate change to the oil, coal and natural gas industries are fully recognized in the investment and lending decisions of major public pensions and banks in the country.
As the divestment movement has spread to the financial community, much of its focus has shifted from social activism to portfolio management. Divestment campaigns were originally motivated by concerns that anthropogenically induced climate change threatens human civilization with potentially catastrophic consequences arising from a wide range of impacts, including the increased incidence of extreme weather events, threats to world food production, widespread island and coastal flooding from rising sea levels, and the migration of diseases.

Walker, Thomas J., Kerstin Lopatta, and Thomas Kaspereit. "Corporate sustainability in asset pricing models and mutual funds performance measurement." ***Financial Markets and Portfolio Management*** **28.4 (2014): 363-407.**
This study explores whether corporate sustainability is a relevant factor in multifactor asset pricing models. It contributes to the literature on asset pricing, as well as to the literature that examines how sustainability impacts capital markets, by constructing a new factor that captures differences in the returns of sustainable and non-sustainable firms. Specifically, it examines whether an additional sustainability factor has explanatory power in asset pricing models that include size, book-to-market equity, and momentum factors. This research has practical implications for the performance measurement of portfolios and mutual funds that are managed in accordance with sustainability criteria in that it disentangles general stock-picking skills from the differences in returns between sustainable and non-sustainable stocks.

Weber, Olaf, Marco Mansfeld, and Eric Schirrmann. "The financial performance of RI funds after 2000." ***Responsible investment in times of turmoil*****. Springer Netherlands, 2012. 75-91.**
More and more investors integrate social and environmental criteria into their investment decisions (Kasemir et al. 2001). Thus the number of investment funds in the socially responsible investment (SRI) sector has increased correspondingly. In 2007 there were 313 SRI funds available in Europe (Eurosif 2007). Those funds strive for satisfying the needs of the investors with respect to social and environmental impacts (Koellner et al. 2007). But do those funds offer a satisfying financial return as well? How did those financial products perform financially in times of turmoil like in the past years? Additionally to their performance with respect to sustainability, the environment, or ethical criteria, SRI funds are expected to perform financially in a sustainable way as well. Only then they guarantee a positive long term financial return and acceptable financial risks.