frontiers in Environmental Science

FIELD GRAND CHALLENGE
published: 10 March 2016
doi: 10.3389/fenvs.2016.00016

Environmental Sciences in the Twenty-First Century

Martin J. Siegert *

Grantham Institute and Department of Earth Science and Engineering, Imperial College London, London, UK

Keywords: climate change, environment, pollution, policy, IPCC AR5

All of us live in two worlds. One is the human world, which includes populations, countries, cities, roads, rail lines, shipping lanes and flight paths. It is the most familiar world and we consciously interact with it every day. It is a world entirely of our construction. It is the world of civilization, of education and of science.

The other is the natural world, with mountains, rivers, continents, forests, animals, clouds and oceans. It provides the air we breathe, the materials we build our homes with, the energy to power our factories, the food we eat and the water we drink. And it is the world we most often take for granted.

Our human world rarely changes substantially without there being conflict or upheaval. In our natural world significant change is normal, however. As it happens, growth of human civilization has occurred during, and probably as a consequence of, a remarkably stable short episode in Earth history—the post glacial Holocene period (the last 10,000 years or so).

Most people in developed nations interact with the natural world without knowing or appreciating it. We drive our cars effortlessly up hills. We fly between continents in a few hours. We turn the taps on for drinking water. We may moan about the weather, but when it turns bad, we have the assurance from personal experience to believe it will pass and we take shelter until it eases.

Today's civilization, based on commerce and trade and the wealth that is generated, has been hugely affected, albeit unwittingly, by the natural world. That the UK was at the epicenter of the industrial revolution was a direct consequence of its geology being ideal for the steam age (coal and iron ore), its weather being suitable for crop and arable farming (mild and wet), and its location as an island nation enabling it, for an important period, to build the world's largest navy to police global trade (it even had sufficient oak to construct that navy). The UK, and many other similarly disposed nations, has excelled at exploiting its natural world offerings, to further develop its human world.

Global long-term economic growth has followed, in spite of episodes of major international conflict, as a consequence of this undeniable human strength. A seemingly endless supply of resources has been exploited to continue our insatiable desire for wealth, acquisition and appropriation. But, as we now know, at some stage since the industrial revolution, and as a consequence of expanding population and consumption, this exploitation has become both damaging and unsustainable.

That is to say, we are using the resources of the natural world to their exhaustion, and the discarded waste products of the industrial processes that feed on them adversely affect the global environment.

The increase in atmospheric greenhouse gas concentration, from fossil fuel emissions, has driven climate warming and, with it, sea level rise (Stocker et al., 2013). Our oceans are also warming, becoming more acidic and are being filled with plastics and other pollutants to a level that seems non-reversible in the short term. Huge areas of natural forests have been destroyed in favor of farmland, which has an increased monetary value but offers less in terms of carbon dioxide uptake and natural habitats. As a consequence we have caused an irrevocable reduction in biodiversity.

OPEN ACCESS

Edited by:
Stuart E. Bunn,
Griffith University, Australia

Reviewed by:
Mark Stafford Smith,
CSIRO, Australia

***Correspondence:**
Martin J. Siegert
m.siegert@imperial.ac.uk

Received: *16 October 2015*
Accepted: *26 February 2016*
Published: *10 March 2016*

Citation:
Siegert MJ (2016) Environmental Sciences in the Twenty-First Century. Front. Environ. Sci. 4:16. doi: 10.3389/fenvs.2016.00016

Most humans now live in cities, cosseted, and protected from the natural world that we came from. As a result, many of us have lost connection with it. It is entirely possible for the majority of humans to live their entire lives within the confines of urban built environments, yet still be dependent on resources from outside it.

We have known for some time that our human world cannot continue to exploit the natural world without profound and likely adverse consequences to civilization, yet we appear hamstrung in attempts thus far to deal with the problem.

Environmental sciences form the study of the natural world and its interaction with society. We do it because curiosity drives us to understand the planet we inhabit, and also because our human world requires this knowledge. The question we face concerns whether and how the natural world can sustainably support our human world. This question, and the myriad associations with it, represents the new "grand challenge" for the environmental sciences.

As we now know that natural and human systems are interconnected, in a multiplex manner, the study of a single aspect of the environment—essential to build knowledge and make observations—cannot be made without comprehension of the external factors that influence it, or that it influences. There are many ways to exemplify this point. The increase in ocean acidity, leading to marine biological consequences (Boyd, 2011), knock-on effects to fisheries and, through this, economies of regions and nations dependent on fishing. Reduction in the volume of stored groundwater, due to over-extraction as a consequence of increased demands of farming and urban consumption (Konikov and Kendy, 2005). The effects on air quality, and therefore public health, due to industrial and transport pollution in major cities (Zhang and Gu, 2013). And, of course, how these, and many more, examples will likely worsen under projected global warming over the coming decades (Stocker et al., 2013).

It is undeniable that the human world's exploitation of the natural world has caused considerable and widespread changes to the natural systems on the planet. Global warming, as a consequence of the industrial emission of greenhouse gases, has led to a measurable surface air temperature increase of ∼1°C since 1880 and sea-level rise of ∼20 cm over roughly the same period (Stocker et al., 2013). It has also increased the level of moisture in the atmosphere, which in turn is thought to have contributed to extreme weather events witnessed across the planet. As ice core records from Greenland and Antarctica reveal, when the planet's climate changes the transition involves short-term major and rapid shifts in temperature and atmospheric conditions (Steffensen et al., 2008); the links between ice, ocean, atmosphere and biosphere causing feedbacks and amplifications between their systems.

There has never been a more important time to study and practice environmental sciences. There are still major discoveries to be made about our natural world, not least in Antarctica—where my own research is based—and such research can be justified by curiosity alone. That said, environmental sciences cannot exist solely for their own sake. Society's "grand challenge" demands we form policies that first restrict and then reduce to zero greenhouse gas emissions by the end of the century. Noxious exhaust emissions must be curtailed by the electrification of the energy and transport systems. Issues concerning genetically modified plants and diets require global solutions for us to plan a sustainable food industry (Gilbert, 2013). Management of our water resources needs continual development as urbanization further intensifies. Environmental sciences are at the epicenter of these issues. Because of this, environmental scientists must reach out and engage with those requiring knowledge and advice. Doing so will lead to better policy and gives us the chance of forming the preferred development of our human world.

Of course this reads like an advert for the findings and recommendations of the Intergovernmental Panel on Climate Change, and I am pleased to offer it as such. But the cross-disciplinary engagement required must stretch far beyond the IPPC, to all levels of the environmental sciences and beyond. Society's grand challenge is environmental sciences' *raison d'être* and we must step up and embrace the role required of us.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and approved it for publication.

REFERENCES

Boyd, P. W. (2011). Beyond ocean acidification. *Nat. Geosci.* 4, 273–274. doi: 10.1038/ngeo1150

Gilbert, N. (2013). Case studies: a hard look at GM crops. *Nature* 497, 24–26. doi: 10.1038/497024a

Konikov, L. F., and Kendy, E. (2005). Groundwater depletion: a global problem. *Hydrogeol. J.* 13, 317–320. doi: 10.1007/s10040-004-0411-8

Steffensen, J. P., Andersen, K. K., Bigler, M., Clausen, H. B., Dahl-Jensen, D., Fischer, H., et al. (2008). High-resolution greenland ice core data show abrupt climate change happens in few years. *Science* 321, 680–684. doi: 10.1126/science.1157707

Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., et al. (eds.). (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. New York, NY: Cambridge University Press.

Zhang, Y., and Gu, Z. (2013). Air quality by urban design. *Nat. Geosci.* 6:506. doi:10.1038/ngeo1869

Conflict of Interest Statement: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.