ELSEVIER

Journal of Historical Geography 35 (2009) 279–296

JOURNAL OF HISTORICAL GEOGRAPHY

www.elsevier.com/locate/jhg

Conventions of climate change: constructions of danger and the dispossession of the atmosphere

Diana M. Liverman

Environmental Change Institute, School of Geography and the Environment, South Parks Road, Oxford OX1 3QY, United Kingdom

Abstract

Climate change has emerged as one of the key issues of the early years of the twenty-first century, bringing together concerns about human relations to nature, the responsibility of rich nations to poorer, the links from local activities to global conditions, and the obligations of present to future generations. This paper focuses on three key 'narratives' that are enshrined in international climate policy – asserting that 'dangerous climate change' is to be avoided; that the responsibility for climate change is common but differentiated; and that the market (in the form of carbon trading) is the best way to reduce the danger. The goal of the paper is to analyse the origins of these narratives, the power relations they reflect and promote, and some of the concepts and images used to support them, including those of climate determinism, climate stabilisation, 'burning embers', 'tipping points', Global Warming Potentials, targets and timetables, and carbon credits. I argue that by choosing the market solution of trading carbon we have created a new and surreal commodity, unfairly allocated pollution rights to nation states based on 1990 emission levels, and established a new set north–south relations and carbon transactions in the name of sustainable development.

Keywords: Climate change; Climate policy; Kyoto; UNFCCC; Carbon trading; Narrative

Introduction

Climate change has emerged as one of the dominant international issues of the early years of twenty-first century, bringing together concerns about human relations to nature, the

E-mail address: diana.liverman@eci.ox.ac.uk

0305-7488/$ - see front matter
doi:10.1016/j.jhg.2008.08.008

responsibility of rich nations to poorer, the links from local activities to global conditions, and the obligations of present to future generations. At the international level the response to climate change has become framed by three key 'narratives' – asserting that 'dangerous climate change' must be avoided; that the responsibility for climate change is common but differentiated; and that the market – in the form of carbon trading – is the best way to reduce the danger. These narratives are particularly powerful because they are formalised in international climate conventions that include the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the 1997 Kyoto Protocol.

This paper argues that these narratives tend to obscure the historical geographies of anthropogenic climate change and have fostered solutions that are often unequal and somewhat ineffective in reducing the risks. The narratives have been employed to design an international response to climate change that has been influenced by powerful political interests and has embraced the neoliberal project of market environmentalism. This response has resulted in emission reductions that are modest to date, even as climate science has argued that the risks are greater than originally conceived.

These three narratives were allocated enormous political and discursive power through their role in international legal conventions. Every time the parties to the Kyoto protocol and the Framework Convention come together in negotiations – such as those in Bali in December 2007 – tense discussions centre on the significance of avoiding dangerous climate change, ensuring common but differentiated responsibility, and promoting carbon markets as well as on the relevant science, institutions and rules needed to implement them.

The analysis in this paper focuses on the political economy and inequality underlying and promoted by these three narratives and their implementation within international relations and geographies. As suggested in recent work by Bulkeley, Okereke and Schroeder, insights into climate governance can be gained from combining elements of neo-Gramscian and governmentality approaches to examine power, the relation between public and private and structure and agency, and the exercise of these relationships through a range of institutions.[1] Critical scholars of international climate policy have examined both power relations and discourses, especially those associated with carbon markets and the role of non-state actors and have linked climate policy with neoliberal environmentalism. For example, Biermann describes the evolution of global environmental policy from command and control collective regulation in the 1970s to a market and trade approach in the 1990s as consistent with a liberal political economic order of free trade, markets and private property.[2] Similarly, Paterson argues that carbon emission reductions have been framed as a modern economic and ecological strategy consistent with accumulation by powerful political actors including renewable energy and insurance companies.[3] Insights are also offered by

[1] C. Okereke, H. Bulkeley and H. Schroeder, Conceptualizing climate change beyond the international regime, *Global Environmental Politics*, in press.

[2] Biermann, F. Science as power in international environmental negotiations: global environmental assessments between North and South, Environment and Natural Resources Program, Discussion Paper no. 2000–17, 2000, Cambridge, Mass.: Belfer Centre for Science and International Affairs, John F. Kennedy School of Government, Harvard University.

[3] M. Paterson, Climate policy as accumulation strategy: the failure of COP6 and emerging trends in climate politics, *Global Environmental Politics* 1(2) (2001) 10–17.

those working more generally on neoliberalism and environmental governance, including careful studies that emphasise issues of property rights and the heterogeneous landscapes of privatisation and commodification, and the roles of re-regulation in neoliberal processes of environmental governance.[4]

Hajer uses ideas of governmentality and discourse to analyse the shifts in international environmental management towards ecological modernisation and market solutions.[5] This analysis is reinforced by Oels who suggests that the governance of climate change has shifted from an environmental issue based on the biopower of data collection and computer modelling to an economic question of neoliberal governmentality through market and technology solutions.[6] Backstrand examines discourses (shared ideas, concepts, practices) used to discuss climate policy and carbon forestry, and the power of different agents to promote, control and institutionalise them.[7] She examines the evolution of the debate over tree plantations as carbon sinks in the developing world using three core discursive themes – ecological modernisation with market solutions, green governmentality through scientific expertise, and civic environmentalism through participation and partnerships. Demeritt argues that social constructions of climate science in the form of climate models and the 'hockey stick' curve of historical global temperatures have influenced approaches to managing climate change.[8] Bulkeley places climate governance within the 'risk society' and as negotiated through discourse coalitions.[9] Slocum employs feminist science studies to interrogate the representation of climate change by NGOs.[10]

This paper builds on these studies to examine three primary narratives formally enshrined in international climate agreements and the political economy they reflect and promote. It also

[4] K. Bakker, Neoliberalizing nature? Market environmentalism in water supply in England and Wales, *Annals of the Association of American Geographers* 95(3) (2005) 542–565; G. Bridge, The social regulation of resource access and environmental impact: production, nature and contradiction in the US copper industry, *Geoforum* 31(2) (2000) 237–256; G. Bridge and A. Jonas, Governing nature: the re-regulation of resource access, production, and consumption, *Environment and Planning A* 34 (2002) 759–766; J. McCarthy and S. Prudham, Neoliberal nature and the nature of neoliberalism, *Geoforum* 35(3) (2004) 275–283; N. Castree, From neoliberalism to neoliberalisation: consolations, confusions, and necessary illusions, *Environment and Planning A* 38 (2006) 1–6; N. Castree, Commodifying what nature?, *Progress in Physical Geography* 27(3) (2003) 273–297.

[5] M. Hajer and W. Versteeg, A decade of discourse analysis of environmental politics: achievements, challenges, perspectives, *Journal of Environmental Policy & Planning* 7(3) (2005) 175–184; M.A. Hajer, *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*, Oxford, 1997.

[6] A. Oels, Rendering climate change governable: from biopower to advanced liberal government?, *Journal of Environmental Policy & Planning* 7(3) (2005) 185–207.

[7] K. Bäckstrand and E. Lövbrand, Planting trees to mitigate climate change: contested discourses of ecological modernization, green governmentality and civic environmentalism, *Global Environmental Politics* 6(1) (2006) 50–75.

[8] D. Demeritt, Science studies, climate change and the prospects for constructivist critique, *Economy and Society* 35(3) (2006) 453–479; D. Demeritt, The construction of global warming and the politics of science, *Annals of the Association of American Geographers* 91(2) (2001) 307–337; D. Demeritt, Social theory and the reconstruction of science and geography, *Transactions of the Institute of British Geographers* 21(3) (1996) 484–503.

[9] H. Bulkeley, Governing climate change: the politics of risk society?, *Transactions of the Institute of British Geographers* 26(4) (2001) 430–447; H. Bulkeley, Discourse coalitions and the Australian climate change policy network, *Environment and Planning C: Government and Policy* 18(6) (2000) 727–748; H. Bulkeley, Reconfiguring environmental governance: towards a politics of scales and networks, *Political Geography* 24(8) (2005) 875–902.

[10] R. Slocum, Polar bears and energy-efficient lightbulbs: strategies to bring climate change home, *Environment and Planning D: Society and Space* 22(3) (2004) 413–438.

analyses the policy and equity impacts of these ideas in terms of material emission reductions and resource flows.[11] The paper is structured to examine each of the narratives in turn – avoiding dangerous climate change, allocating responsibility, and market solutions – and for each examines their origins and implications for the geographies of climate policy. The historical significance of these narratives lies in their impact on the environmental, energy and economic development policies of many countries, their role in the creation of carbon as a new commodity, and the structuring of a new set of international relations around responsibility for causing and solving climate change.

Constructing the idea of dangerous climate change

The origins of international concern about the risks of anthropogenic climate change are often traced to the publication of the Mauna Loa series of measurements of a rise in the carbon dioxide content of the atmosphere. This was linked to the rise in consumption of fossil fuels, and a one-dimensional radiative balance analysis of what this might mean in terms of global temperatures.[12] By the early 1980s climate scientists were using more complex models of the atmospheric circulation and producing global maps of changes in temperature associated with the climate's sensitivity to a doubling of CO_2 concentrations. Coloured to show increasing temperatures in reds and oranges, these maps conveyed a striking image of a warming world. However, the maps oversimplified the geographies of climate change because they were based on very coarse resolution models with simple geography, weak representation of precipitation and soil moisture, no representation of uncertainty, and focused only on some hypothetical equilibrium state at which carbon dioxide concentrations would have doubled over preindustrial levels. In practice, this meant that for any one location, information was only available on the average temperature change for a 400–1000 sq km grid square that might occur when concentrations reached 550 ppm of CO_2 compared to a model simulation of current conditions.[13]

The emergent climate impacts community sought to convert model results to risks facing resource systems and the economy.[14] Many impact studies (including my own) were little more

[11] The analysis in this paper is based on a series of texts that document thirty years of climate science and politics, personal experience as an observer of negotiations and contributor to international climate science, and interviews conducted for two research projects: (i) a comparative project where we sought to understand learning about atmospheric risks and the relation to policy globally and in particular countries: W. Clark, C. Van Eijndoven, and J. Jaeger, *Learning to Manage Global Environmental Risks: a Comparative History of Social Responses to Climate Change, Ozone Depletion, and Acid Rain*, Boston, 2001; (ii) a Tyndall Centre research project on post-2012 climate policy where we focus in particular on the role of non nation state actors in the international climate regime (see www.tyndall.co.uk).

[12] Some of the classic papers include R. Revelle and H.E. Suess, Carbon dioxide exchange between atmosphere and ocean and the question of an increase of atmospheric CO_2 during the past decades, *Tellus* 9 (1957); C.D. Keeling, Is carbon dioxide from fossil fuel changing man's environment?, *Proceedings of the American Philosophical Society* 114 (1970) 10; S. Manabe and R.T. Wetherald, The effects of doubling the CO_2 concentration on the climate of a general circulation model, *Journal of the Atmospheric Sciences* 32(1) (1975) 3–15. A useful review article is C.D. Keeling, Rewards and penalties of monitoring the earth, *Annual Review of Energy and the Environment* 23(1) (1998) 25–82.

[13] S.H. Schneider, Climate modeling, *Scientific American* 256, 5 (1987) 72–80; K. McGuffie and A. Henderson-Sellers, *A Climate Modelling Primer* (and CD), Chichester, 1997.

[14] R.W. Kates, J. Ausubel and M. Berberian, *Climate Impact Assessment: Studies of the Interaction of Climate and Society*, Chichester, 1985; J.B. Smith and D.A. Tirpak, *The Potential Effects of Global Climate Change on the United States: Report to Congress*, Washington DC, 1988.

than sensitivity analyses of crop yields or water supply where temperatures were increased by 2 °C and precipitation uncertainties were addressed by looking at both increases and decreases of 20%.[15] The studies were also limited in terms of looking only at changes in climate with no attention to other likely social, technological and economic trends, to the possibilities of adaptation, or to the onward risks to food and water security. By focusing only on the changes in the climate, with limited attention to political economy or human agency, these analyses echoed earlier traditions of environmental determinism which saw climate as the dominant factor in economic and human development.[16]

The resultant geographies of climate risk generally took the form of calculations and maps that were based on weak evidence as to changes in precipitation, ignored the transition to and beyond a CO_2 doubling, focused on yields of only a few crops and on water supply (rather than food security, health or ecosystems), did not take account of other social or environmental changes or of adaptation, and provided little information as to the vulnerabilities and impacts on individual countries, communities or individuals. The developing world was poorly served by a lack of research on changes in the monsoon, El Nino, and hurricanes; by a lack of attention to traditional crops such as pulses, roots and oilseeds; and by a lack of research on adaptive capacity, ecosystems and health in tropical regions.

Nevertheless these assessments were enough to provoke a small but influential group of scientists to build the case for institutions and policies to coordinate research and responses to the risks of climate change. A series of meetings and reports between 1985 and the Rio Summit in 1992 laid the scientific groundwork for an international agreement on climate change.[17] The World Meteorological Organisation (WMO) sought to impose discipline on the scientific debate about climate change through proposing the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988, whose first assessment (in 1990) brought together information on the science, impacts and responses to climate change. Whilst the IPCC has been criticised from both an empirical and constructivist perspective for, among other things, overstating certainty, having a northern bias, and forcing consensus, it has become a powerful institution within the international climate regime and is a point of referral in negotiations and political declarations, receiving the Nobel Peace prize in 2007.[18]

The 1988 Toronto Conference on the Changing Atmosphere laid the basis for international agreement in calling for a 'comprehensive international framework that can address the

[15] R.A. Warrick, Carbon dioxide, climatic change and agriculture, *Geographical Journal* 154, 2 (1988) 221–233; W.H. Terjung, D.M. Liverman and J.T. Hayes, Climatic change and water requirements for grain corn in the North American Great Plains, *Climatic Change* 6(2) (1984) 193–220.

[16] K.M. McGregor, Huntington and Lovelock: climatic determinism in the twentieth century. *Physical Geography* 25(3) (2004) 237–250.

[17] WMO, *International Assessment of the Role of Carbon Dioxide and of Other Greenhouse Gases in Climate Variations and Associated Impacts*, Villach, Austria, 1985.

[18] S. Agrawala, Context and early origins of the Intergovernmental Panel on Climate Change, *Climatic Change* 39(4) (1998) 605–620; D. Liverman, Assessing impacts, adaptation and vulnerability: reflections on the Working Group II Report of the Intergovernmental Panel on Climate Change, *Global Environmental Change* 18, 1 (2008) 4–7; J. Robinson and A. Shaw. Imbued meaning: science-policy interaction in the IPCC, in: *Proceedings of the 2002 Berlin Conference on the Human Dimensions of Global Environmental Change*, Berlin, 2002; Demeritt, Science studies (note 8); Demeritt, The construction of global warming (note 8); Clark et al., *Leaving to Manage* (note 11).

interrelated problems of the global atmosphere'. Among its recommendations were the reduction of carbon dioxide emissions by 20% of 1988 levels by the year 2005; the preparation of the principles and components of a framework treaty for the protection of the atmosphere (including climate change, ozone depletion, and atmospheric pollution) in time for the 1992 UN Conference on Environment and Development (UNCED); and the promotion of the Intergovernmental Panel on Climate Change.[19] Negotiations to develop a formal convention on climate change began in 1990 under the auspices of the WMO and UN Environment Programme (UNEP) with the involvement of 150 nation states and a number of NGOs. The convention was presented to the UN Conference on Environment and Development in June 1992 and signed by 154 nation states and the European Economic Community.

The core of the convention is the goal set out in Article 2 – the 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. This embraces one of the dominant discourses of international environmental law – the 'precautionary principle'.[20] The precautionary principle was a key clause in the Rio conference where it was agreed that 'where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.' The challenge of Article 2 and the precautionary principle is the undefined and subjective use of terms such as 'dangerous' and 'serious' and the attribution problems posed by the focus on 'anthropogenic interference'. Dangerous anthropogenic interference has generally been measured in terms of emissions, concentrations or temperature changes that can be linked to impacts of concern. The IPCC Second Assessment in 1995 projected a mid range emission scenario associated with a global temperature increase of 2 °C by 2100, and identified 'potentially serious changes' of increases in the incidence of extreme high-temperature events, floods and droughts, with consequences for fires, pest outbreaks, and ecosystems.[21] The 2 degree level became an enduring benchmark of danger and a metric that then constrained emission and concentration targets.

One of the more significant ideas in the IPCC Second Assessment report was that the degree of danger or severity of impacts was affected as much, if not more, by the distribution and dynamics of the 'vulnerability' of people and ecosystems and thus by socioeconomic conditions in addition to physical environmental changes. This complicated the definition of danger because it implied that some vulnerable places and people could be at risk from even small changes (i.e. below 2 degrees) whereas others could cope, or might benefit, from larger changes.

The IPCC Third Assessment in 2001 highlighted the problems in responding to Article 2 of the FCCC stating that 'Natural, technical, and social sciences can provide essential information and evidence needed for decisions on what constitutes ''dangerous anthropogenic interference with the

[19] WMO, in: *Proceedings of the World Conference on the Changing Atmosphere: Implications for Global Security*, Toronto, Canada, June 27–30, Geneva, 1989.

[20] P.H. Martin, If you don't know how to fix it, please stop breaking it! The precautionary principle and climate change, *Foundations of Science* 2(2) (1997) 263–292; J.K. Hammitt, Global climate change: benefit-cost analysis vs. the precautionary principle, *Human and Ecological Risk Assessment* 6(3) (2000) 387–398.

[21] R.T. Watson, M.C. Zinyowera and R.H. Moss, *Climate Change, 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-technical Analyses: Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, 1996.

climate system''. At the same time, such decisions are value judgements determined through socio-political processes, taking into account considerations such as development, equity, and sustainability, as well as uncertainties and risk. The basis for determining what constitutes ''dangerous anthropogenic interference'' will vary among regions—depending both on the local nature and consequences of climate change impacts, and also on the adaptive capacity available to cope with climate change—and depends upon mitigative capacity, since the magnitude and the rate of change are both important'.[22]

Since the Third IPCC report, considerable scientific effort has gone into trying to estimate a level of greenhouse gas concentrations that would avoid dangerous climate change including a major conference coordinated by the UK government in Exeter in 2005.[23] At the Exeter conference it became clear that previous assumptions about 'safe' concentrations of greenhouse gases – such as the 550 ppm used in many studies – might result in changes perceived as dangerous, especially because of impacts already observed at the current concentration of about 380 ppm, because of the possibility of rapid and discontinuous climate change at concentrations lower than 550 ppm, and because ensemble climate model results showed significant risks of exceeding 2 degrees. Meinshausen for example, argues that there is a 75% chance of overshooting 2 degrees at 550 ppm, and that even 5 years delay increases risks and abatement efforts.

'Preventing dangerous anthropogenic interference' gained policy traction when the EU adopted a goal that assumed that stabilisation at 550 ppm of carbon dioxide equivalent in the atmosphere would produce an acceptable change of 2 °C. This is problematic because even at 2 degrees some changes will be perceived as dangerous, especially for the vulnerable, and because it may not be possible to guarantee an emissions target that keeps climate below a 2 degree change.

Attempts to explore the subjective meaning of 'dangerous' have highlighted the significance of scale and of perception in the interpretation of Article 2. For example, Dessai and colleagues suggest that the type of measured external risks that are the focus of IPCC must be contrasted to the internal social perceptions and lived experience of danger.[24] Article 2 provides no indication of the spatial scale that should be examined for 'dangerous anthropogenic interference' although what is considered safe for the earth system or economies at the larger scale may be extremely dangerous for people and ecosystems at the local scale such as those living on low lying islands or reliant on glaciers and snow for water supplies. Climate change can produce minor impacts at the global or national level (in terms of ecosystem change or aggregate GNP) but can produce overwhelming losses at the local scale (in terms of the loss of a forest, wetland, production or residential area). This is partly because in aggregation, large losses in one region are balanced by benefits or minor losses in others as a result of variations in the specific local impacts of climate changes and in vulnerability.

Two powerful images have emerged from the attempts to define and communicate dangerous climate change, each underpinned by a large number of scientific analyses and legitimated through publication and republication. The first is the image that has been called 'Burning Embers' and

[22] R. Watson, *Climate Change 2001: Synthesis Report, Summary for Policymakers*, Bonn, 2001.

[23] H.J. Schellnhuber, W. Cramer, N. Nakicenovic, T. Wigley and G. Yohe, (Eds), *Avoiding Dangerous Climate Change*, Cambridge, 2006 especially the paper by M. Meinshausen, On the Risk to Overshoot 2 °C.

[24] S. Dessai, W.N. Adger, M. Hulme, J. Turnpenny, J. Köhler and R. Warren, Defining and experiencing dangerous climate change, *Climatic Change* 64(1) (2004) 11–25.

used to summarise the risks of climate change to the planet and its occupants. The second is the 'Tipping Points' map which shows potential discontinuities in the climate system. Both images surfaced in high level political hearings – in submissions to the Stern Review in the UK and in testimony to senate committees in the US.

Burning Embers' (Fig. 1) appeared in the Third Assessment Report for Working Group II of the IPCC as a way to summarise the key concerns about dangerous climate change. A schematic rather than a quantitative appraisal, it is rife with value judgements and complex to interpret. On the left hand side of the diagram are the projections of temperature changes associated with a variety of emission scenarios suggesting that global temperatures could rise by 1–6 °C by 2100, depending on greenhouse gas emission trajectories and on their climate impact simulated by various climate models. The right hand part of the figure shows the level of danger associated with these temperature changes for each of five areas of concern, with red associated with larger or more widespread impacts. The first column shows that there are serious risks to unique and threatened systems and the second column risks from extreme climate events at even moderate temperature increases. At a 2 degree global warming there are risks associated with unequal impacts and of damages to the aggregate economy. At higher temperatures there are greater risks of large scale climate discontinuities. The yellow to deep red shading gave rise to the label 'burning embers'. A version of the image appears in the widely read Stern Review on the Economics of Climate Change.[25]

This image generally overlooks the spatial geographies of climate change. 'Unique and threatened systems' are identified as glaciers and lakes, mountain, arctic, coral and wetland ecosystems, as well as small island states and indigenous communities. Colder and coastal ecosystems dominate the definition of unique and threatened although the scientific evidence points to considerable vulnerabilities in dryland and other tropical ecosystems. The focus only on Small Island and indigenous societies is a very narrow view of how we might rank and value the uniqueness and vulnerability of global cultures. The IPCC itself notes that the basis for the assessment of unequal impacts – the analysis of distributional impacts – is weak because of difficulties in model downscaling and the complex role of social vulnerability and adaptation.

Aggregate impacts are measured for the diagram in terms of financial impact, specifically gross domestic product (GDP) and are highly dependent on assumptions about valuation and discounting. Alternative indicators such as millions of lives at risk must also take into account the uncertainties of vulnerability and adaptation. The final column – concerned with extreme and irreversible effects – includes major disasters such as the collapse of the North Atlantic thermohaline circulation (THC) or the West Antarctic ice sheet (WAIS). In this case the full human geographical implications have not been analysed nor combined with the possibilities of parallel or countervailing discontinuities in the social system.

The collapse of the THC and WAIS are portrayed on the map of Tipping Points (Fig. 2) that first emerged in work by Held and Schellnhuber as a way of communicating the risks of

[25] For discussions and use of the Burning Embers graphic see F. Yamin, Burning embers and beyond: the role of typologies in defining dangerous outcomes, in: H.J. Schellnhuber (2006); M. Grubb, Framing the Economics of Climate Change: Submission to the Stern Review on the Economics of Climate Change, 2006, http://www.hm-treasury.gov.uk/media/FCF/59/climate_change_grubb.pdf [accessed Nov 15 2006]; N. Stern, *The Economics of Climate Change: the Stern Review*, Cambridge, 2007.

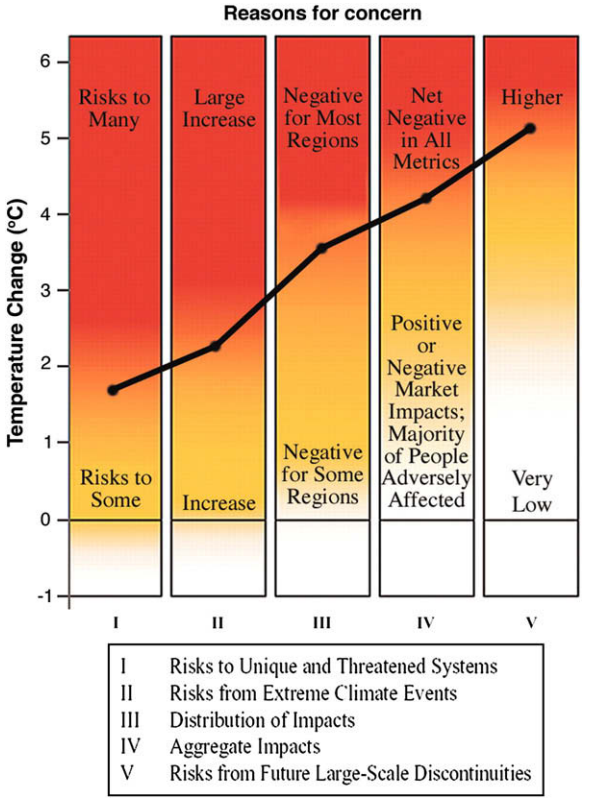

Fig. 1. The 'Burning Embers' diagram from IPCC Third Assessment Report with EU stabilisation target superimposed on emission scenarios. Source: Intergovernmental Panel on Climate Change, Summary for Policy Makers: Climate Change 2001: Impacts, Adaptation & Vulnerability Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland, 2001.

discontinuous changes in the earth's system.[26] The map portrays zones where global warming could trigger abrupt climate changes including the collapse of the West Antarctic Ice Sheet and Amazon forest, the shutdown of the North Atlantic Thermohaline Circulation, the release of Siberian and ocean floor methane and increases in the intensity of El Nino and the monsoon. It has been proposed as an icon for the risks of climate change but again, danger is defined from an earth systems perspective. The map only looks at biophysical systems, and locates the source rather than the impacts of the changes with no sense of relative probabilities or human implications.

I would argue that the stories of dangerous climate change conveyed in these powerful images of 'burning embers' and 'tipping points' are predominantly biophysical, with human systems and

[26] H.J. Schellnhuber and H. Held, Evolution of perturbations in complex systems, in: A.S.W. Steffen, J. Jäger, P.D. Tyson, I.I.I.B. Moore, P.A. Matson, K. Richardson, F. Oldfield, H.J. Schellnhuber, I.I.B.L. Turner and R.J. Wasson (Eds), *Global Change and the Earth System: a Planet Under Pressure*, Berlin, 2004; M. Kemp, Science in culture: inventing an icon, *Nature* 437, 7063 (2005) 1238; T.M. Lenton, H. Held, E. Kriegler, J.W. Hall, W. Lucht, S. Rahmstorf and H.J. Schellnhuber. Tipping elements in the Earth's climate system. *Proceedings of the National Academy of Sciences* 105 (2008) 1786–1793.

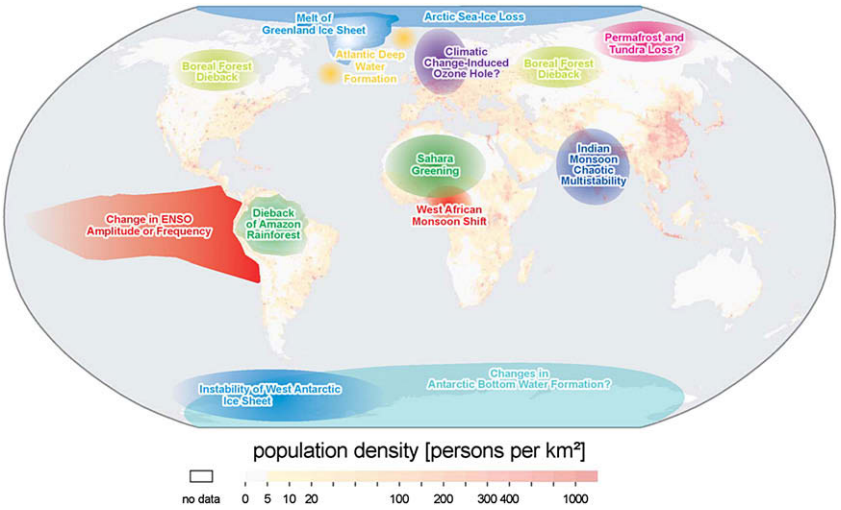

Fig. 2. Tipping Points in the earth system. Source: M. Kemp, Science in culture: inventing an icon, *Nature* 437, 7063 (2005) 1238.

geographies relatively unexplored or obscured. As in the earlier days of climate impact assessment the approach tends towards an environmental determinism driven by climate science and lacks a nuanced analysis of vulnerability and the distribution of risks and capacity to adapt to them. The narrative of preventing dangerous anthropogenic interference with the climate system (and the images used to convey it) is significant because it frames the major international agreement on climate change yet is fundamentally too subjective to provide targets for emission caps. It also demands results from climate science that are difficult to provide – an objective measure of risk and of anthropogenic influence, a comprehensive damage assessment, and a clear link from emissions to concentrations to climate to impacts that cannot confidently be made with geographically patchy research that underemphasises certain regions, sectors and much social science.[27]

Allocating responsibility for climate change

A second grand narrative of climate policy is the concept of 'common but differentiated responsibility' for climate change as formalised in Article 3(1) of the Framework Convention. The blame for anthropogenic climate change and greenhouse gas emissions has been variously assigned to the global collective, to nation states, to economic sectors and to individuals, but because the international climate regime is based on nation states it is the allocation of responsibility to countries that has been the most important and controversial. There are deep contrasts and conflicts in assigning responsibility for global warming that centre on north–south relations, the balance of past and future emissions, and the role of the state, private sector, and individuals. One of the most

[27] Liverman, Assessing impacts, adaptation and vulnerability (note 18).

important techniques underlying the quantification and negotiation of differentiated responsibility has been the development of metrics that combine emissions (and possibly sinks that absorb greenhouse gases) into indices of baseline emissions and responsibility.

One of the earlier debates developed in 1990 around a report by the World Resources Institute (WRI) which ranked countries according to annual emissions of carbon dioxide, methane and CFCs including CO_2 from both fossil fuels and deforestation and methane from rice paddy and cattle.[28] The index also gave credit for carbon sinks (such as forests) but only in relation to emissions. The WRI index ranked the US (index value of 1000), USSR (690), India (230), China (380) and Brazil (610) as the top emitters. The IPCC adopted a similar model in the form of Global Warming Potentials (GWP) which combined radiative potential and residence time to estimate carbon equivalents for six greenhouse gases. The six gases were carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFC), hydrofluorocarbons (HFC) and sulphur hexafluoride (SF_6). As these gases have different potencies in trapping outgoing radiation (e.g. a unit of methane warms more than a unit of CO_2) and atmospheric residence times, they are weighted differently in indices of greenhouse gas responsibility. These metrics became extremely important when it came to the Kyoto Protocol because they were used to calculate the baseline emissions from which emission reduction commitments would be made and because they were the basis for converting different gases into a standard carbon dioxide equivalent (CO_2e) in carbon markets.

The Centre for Science and Environment (CSE) published a scathing critique of the WRI index in 1991 in a report 'Global warming in an unequal world – a case of environmental colonialism'.[29] They argued, first, that there should be a moral difference between those emissions associated with 'survival' (e.g. for basic food and warmth) and 'luxury' emissions (e.g. for large cars). They criticised the use of snapshot baseline data from 1987 which led, for example, to an overestimation of Brazil's emissions because of unusually severe fires in Amazonia. And they attacked the idea that sinks should be allocated based on emissions, arguing that all had an equal right to this global commons and that the ability of the biosphere to absorb emissions should be allocated on an equal and per capita basis, that is to countries based on their population. Converting their proposal to rankings produced a dramatic shift in blame with China (32) and India (0.7) ranking much lower and the US (1532) ranking higher.

Other commentators argued that emission reductions should be according to historical responsibility (putting greater liability on Europe and North America and diminishing the role of developing countries) or should take account of the efficiency of energy and forest use through the use of indicators such as carbon or energy intensity. Historical emissions have contemporary relevance because of the lag effects of long residence times in the atmosphere whereby current emissions contribute to future warming (and past emissions to the warming now being observed). As is the case with most indicators derived at the national level, measures of greenhouse gas responsibility hide enormous inequalities in consumption within countries and are often reliant

[28] World Resources Institute, *World Resources: 1990–91*, New York, 1991; J.K. Mitchell, Greenhouse equity: six commentaries on the WRI/CSE controversy, *Global Environmental Change* 2(2) (1992) 82–100; A.L. Hammond, E Rodenburg and W. Moomaw, Accountability in the greenhouse, *Nature* 347 (1990) 705–706.

[29] A. Agarwal and S. Narain, *Global Warming in an Unequal World: A Case of Environmental Colonialism*, New Delhi, 1991.

on self-interested national reporting. The international climate regime has developed a wide range of rules for reporting emissions but finds it difficult to discipline and enforce accurate reporting.[30]

During the negotiations for the Rio Climate Convention, developing countries were unified – in the form of a G77 block – in emphasizing the historical responsibility of developed countries for climate change. They agreed to participate in the climate negotiations only on the condition that they were not required to accept any substantial commitments of their own.[31]

The 1992 Framework Convention on Climate Change was unable to resolve these controversies except to adopt the general principle of 'common but differentiated responsibility' and to suggest that industrialised countries should act first and provide assistance to the developing world. The principle recognises historical differences in the contributions of developed and developing states to global environmental problems, and differences in their respective economic and technical capacity to tackle these problems. The outcome demonstrated that by acting together the countries of the South could exert some power in international environmental negotiations, at least in principles if not in practice.

In the negotiations between Rio and the signing of the Kyoto protocol in 1997 the question of responsibility was at the core of discussion because it also drove the issue of who should reduce emissions, when, and by how much. At the first Conference of Parties in Berlin, the G77 (a coalition of 77 developing nations within the UN) was able to push for a mandate that agreed that 'the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that the per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs'. This narrative, termed the Berlin Mandate, was sustained in the Kyoto protocol in that developing countries (including some wealthy oil producers) were not given binding obligations to reduce emissions during the first commitment period. However, the idea that historical emissions should be the basis for cuts was rejected in favour of a 1990 baseline for Kyoto, justified because of a lack of good data prior to this year but also because a 1990 baseline favoured several powerful interests including the UK, Germany and Russia.[32] The Kyoto targets took national emissions of 6 greenhouse gases in 1990 and assigned a reduction below this baseline to be achieved on a 2008–2012 timetable.

Even official accounts of the negotiations make the political power struggles over responsibility quite clear.[33] Alliances were created to push for the inclusion of sinks, multiple gases managed as

[30] S. Subak, Verifying compliance with an unmonitorable climate convention, *International Environmental Affairs* 9(2) (1997) 148–168; K. Chomitz, *Baselines for Greenhouse Gas Reductions: Problems, Precedents, Solutions*, Development Research Group, World Bank, Washington, 1998.

[31] J. Depledge, *Tracing the Origins of the Kyoto Protocol: an Article by Article Textual History*. Technical paper FCCC/TP/2000/2, 25 November 2000 Prepared under contract to UNFCCC, Bonn, 2000.

[32] S. Barrett, Political economy of the Kyoto Protocol, *Oxford Review of Economic Policy* 14(4) (1998) 20–39; A. Moe and K. Tangen, Russian climate policies: more than hot air? *Energy & Environment* 12(2) (2001) 181–197; D.G. Victor, N. Nakicenovic and N. Victor, The Kyoto Protocol emission allocations: windfall surpluses for Russia and Ukraine, *Climatic Change* 49(3) (2001) 263–277.

[33] Useful accounts of the climate negotiations are provided by S. Dessai, The climate regime from The Hague to Marrakech: saving or sinking the Kyoto Protocol. *Working Paper 12, Tyndall Centre*, 2001; B.D. Solomon, The origins, practice, and limits of emissions trading, *Journal of Policy History* 14(3) (2002) 293–320; I.M. Mintzer and J.A. Leonard, *Negotiating Climate Change: The Inside Story of the Rio Convention*, Cambridge, 1994; M.J. Larson, Low-power contributions in multilateral negotiations: a framework analysis, *Negotiation Journal* 19(2) (2003) 133–144.

a collected 'basket' rather than individually, for flexible baselines, for delays in the timetables and for differentiated and joint commitments. The G77 wanted a strong uniform emissions cut across the developed world of at least 15%. However, by including sinks (the carbon absorbed annually by forests and other land cover) and suggesting that net current emissions should be the basis of responsibility, countries such as the US hoped to balance their high fossil fuel emissions and reduce their relative responsibilities. Flexible baselines were promoted by Japan (which wanted a 1995 baseline for HFCs which had grown in the early 1990s as a substitute for the CFCs banned in the Montreal ozone protocol) and by some of the former Soviet satellites who wanted the base year to reflect their highest emissions prior to industrial collapse (a high emissions baseline was to the advantage of countries whose economies subsequently decarbonised as a result of the fall of the Iron Curtain). The 1990 baseline was defended by the EU, partly because two of its most powerful members had high CO_2 emissions in 1990 and had already seen inadvertent declines in emissions since – the UK because Margaret Thatcher had crushed the coal unions and promoted a switch to gas (which has lower emissions than coal) and Germany because a unified Germany could take credit for the emissions decline associated with the collapse of East German industry after the fall of the Berlin Wall. The 1990 baseline also benefited Russia and former republics such as the Ukraine, whose emissions also fell dramatically after the dissolution of the USSR at the end of 1991.

The EU initially lobbied for only three gases to be included – CO_2, CH_4 and N_2O – arguing that other industrial gases such as HFCs, with localised sources and high radiative potential, should be regulated separately. The EU also wanted to meet its cuts jointly by making a collective commitment that could then be managed flexibly within a 'bubble' that would allow some states to increase emissions balanced by larger decreases by others. The most vulnerable nations – the Association of Small Island States (AOSIS) – pushed for deep uniform cuts by developed countries, strict baselines, no bubbles or baskets, fewer gases, early timetables and the exclusion of sinks because they were concerned to obtain the maximum possible reduction in atmospheric concentrations as soon as possible.

At the 1988 Toronto Conference on the Changing Atmosphere, scientists and international organizations established a goal of an overall (including developing countries) 20% cut in greenhouse gas emissions by 2005 – less than the 60% needed to stabilise the climate but ecologically significant and what they hoped would be politically realistic. When it came to the final targets in the Kyoto Protocol in 1997 this goal had become drastically watered down, not only by the exclusion of the developing world but also by the compromises discussed above that allowed for flexible baselines, a bubble for the EU, a basket of 6 gases, a timetable delayed to 2012 and the inclusion of sinks.[34] And rather than a uniform cut across the industrialised world, a cut based on historical responsibility, or a cut proportional to emissions, the commitments in the protocol are a product of last minute political compromise managed by the indefatigable diplomat who chaired the negotiations, Argentinean Raul Estrada. Unable to negotiate uniform or other logical targets, Estrada used pledges that had been proposed in discussion to draw up a set of commitments that he felt would allow an agreement to be signed in Kyoto by the maximum number of countries. These were announced early in the morning on the final

[34] D.M. Liverman, Survival into the future in the face of climate change, in: E. Shuckberg (Ed.), *Survival; the 2006 Darwin Lectures,* Cambridge, 2006.

day of the meeting. The final commitments included 8% cut from 1990 baseline for the EU 'bubble', 7% for the US, 6% for Canada and Japan, no cut for Russia and its former satellites such as the Ukraine, and New Zealand, and an 8% increase for Australia. This summed to an overall cut of 5.2% over 1990 levels. Given that the US and Australia played especially heavy hands in the negotiations – with Australia securing a last minute clause not only to increase its emissions but also to include emissions from unusually high 1990 land clearing in its baseline – it is notable that the US or Australia were the only industrialised countries not to ratify the protocol when it went into force without them in 2005. Responsible for 3% (Australia) and 33% (US) of industrialised emissions this reduced the potential effectiveness of the protocol from 5.2% to about 2% (although Australia ratified Kyoto at the end of 2007).[35]

The history that lies behind these negotiations on common and differentiated responsibility reveals an interesting blend of traditional international political power relations including north–south and EU–US tensions. An added element is the shared interest of the small island states with their specific vulnerability to sea level rise and the logics of the former Soviet bloc's economic collapse that brought inadvertent environmental benefits and easy reductions to many countries. And underlying the position of many nation states was the desire to minimise their actual obligation to reduce greenhouse gas emissions by selecting the most beneficial base year, a later timetable, claiming credit for forest and land sinks, and a particular basket of gases.

Many criticisms (from groups such as CSE) can be seen as emerging from anti-colonial and anti-capitalist narratives, disapproving of northern per capita consumption and unequal exchange between north and south. The critique of the Kyoto commitments is mostly framed around questions of climate justice, particularly the balance between low emissions and high vulnerability in the developing world compared to high emissions in the developed world, especially by the United States and by major multinational corporations[36]. These north–south issues are increasing in saliency as negotiators start to plan for the next phase of commitments beyond 2012 when the developing world is expected to take on some form of responsibility for mitigation and there is a greater expectation that funds will be transferred from north to south for adaptation.

The market as solution

Perhaps the most significant idea in creating the international climate regime was the proposal that the market could provide a mechanism for mitigating climate change and meeting Kyoto commitments. Consistent with broader ideologies of market environmentalism and ecological

[35] B. Bolin, The Kyoto negotiations on climate change: a science perspective, *Science* 279 (1998) 330; C. Hamilton and L.Vellen, Land-use change in Australia and the Kyoto Protocol, *Environmental Science and Policy* 2 (1999) 145–152.

[36] W.N. Adger, S. Huq, M.J. Mace and J. Paavola, *Equity and Justice in Adaptation to Climate Change*, Cambridge, 2005; H. Shue, Global environment and international inequality, *International Affairs* 75(3) (1999) 531–545; W. Sachs, Development patterns in the North and their implications for climate change, *International Journal of Global Environmental Issues* 1(2) (2001) 150–162; J. Martinez-Alier, Distributional obstacles to international environmental policy: the failures at Rio and prospects after Rio, *Environmental Values* 2 (1993) 97–124; M. Redclift, *Wasted: Counting the Cost of Global Consumption*, London, 1996; L. Lohmann, *Democracy or Carbocracy? Intellectual Corruption and the Future of the Climate Debate*, 2001, http://www.thecornerhouse.org.uk/item.shtml?x=51982.

modernisation, the US brought a proposal for carbon trading to the second COP in 1996. They presented a narrative that argued the demonstrated effectiveness of cap and trade schemes in controlling sulphur emissions in the US, and that market instruments were the most efficient and cost effective ways of managing pollution.[37] Pollution quotas would be allocated and those who were able to meet and exceed targeted reductions could sell excess pollution credits to those who were unable or unwilling to meet the targets domestically. The US also proposed that commitments could be met rapidly and economically by investing in places and sectors, including those in other countries, where emission reductions could be achieved at lowest cost. This form of 'Joint Implementation' means that a country can meet emission reductions through overseas investment in energy efficiency rather than by domestic cuts. Both trading and joint implementation would reduce the cost of compliance with Kyoto and allow for a more flexible approach to emission reductions and both were included in the final text of the Kyoto protocol despite the strong reservations of the G77, AOSIS and China. Joint implementation was limited to projects between the industrial economies (such as Japan) and economies in transition (such as Poland).

A third 'flexible mechanism' was developed to address the wish of developing countries for some form of compensation within the climate regime and to permit a form of joint implementation between industrialised and developing countries. A proposal from Brazil for the industrial countries to fund low carbon development in the developing world was made more attractive by northern negotiators by proposing that such investments provide credits that could be used to meet commitments rather than make cuts domestically. The 'Clean Development Mechanism' allowed the north to support emission reduction projects in the south – including industrial gas capture, renewables, energy efficiency and forest plantations – in return for credits towards Kyoto obligations and provided a small fund for adaptation through a tax on transactions.[38] The CDM is rapidly becoming the latest development discourse as entrepreneurs and environmental groups approach local communities with projects for carbon sequestration and energy alternatives.

Attempts to limit the scope of these flexible mechanisms included demands that they should be supplementary to other activities, that at least 50% of the commitment should be met domestically (rather than through trade or investment), that CDM projects should be demonstrably additional to what would have happened otherwise, that they should meet sustainable development criteria, and that reductions achieved prior to the onset of trading (i.e. before the protocol came into force) could not generate credits. Only the additionality and sustainability requirements made it into the final agreement, although the EU did impose the 50% domestic requirement within the bubble of the internal European Trading Scheme.

The commodification of carbon emission reductions within the international climate regime has immense theoretical and practical implications.[39] It created a new but highly slippery commodity

[37] Solomon, The origins, practice, and limits of emissions trading (note 33).

[38] E.A. Parson and K. Fisher-Vanden, Joint implementation of greenhouse gas abatement under the Kyoto protocol's 'clean development mechanism': its scope and limits, *Policy Sciences* 32(3) (1999) 207–224; E. Haites and F. Yamin, The clean development mechanism: proposals for its operation and governance, *Global Environmental Change-Human and Policy Dimensions* 10(1) (2000) 27–45; IGES, *CDM and JI in Charts*, Japan, 2005; UNFCCC, *Clean Development Mechanism*, 2006, http://cdm.unfccc.int/.

[39] A. Bumpus and D. Liverman. Accumulation by decarbonisation: the political ecology of carbon offsets, *Economic Geography* 84(2) (2008).

in the form of 'carbon credits' generated from excess emission reductions and international investments in emission reduction projects in the developing world. Because the baseline for the reductions was based on emissions in 1990 the atmosphere was effectively 'enclosed' according to pollution levels in 1990. The larger environmental narrative here is that of 'prior appropriation' whereby those who first polluted the atmosphere then acquire a right to pollute under international law. Any reductions in emissions beyond the Kyoto targets could be sold and any difficulty in meeting targets could be met by purchasing credits or making cheap investments in the developing world.

The discourses of market environmentalism that supported the Kyoto mechanisms included flexibility, economic efficiency, payments for nature's services and sustainable development.[40] But these narratives of ecological modernisation smooth over the profound inequalities that the flexible mechanisms generate, highlighted by groups such as India's Centre for Science and Environment and Cornerhouse. They argue that carbon trading is a new form of colonialism whereby the north is able to maintain its consumption by paying southern communities a pittance to grow trees or by getting credit for the easy 'low hanging fruit' of carbon savings in inefficient industrial projects.[41] A growing number of case studies point to questionable sustainable development benefits of CDM projects.[42] In South Africa, proposed CDM projects for landfill methane capture, gas pipelines and lower carbon housing have been attacked for lack of local participation, injustice and little long term environmental and economic sustainability. In Brazil, forestry plantations have been criticised for lack of additionality and for weak benefits to local communities.

Critics also point to the unfair way in which the pollution rights to the atmosphere were allocated – based on historical emissions rather than population – and the loopholes that were created for certain industrial countries so that they could vary baselines, count sinks, and trade the 'hot air' of reductions achieved inadvertently. For example, by ratifying Kyoto and negotiating a zero reduction commitment Russia gained enormous potential windfall profits from the decline in its emissions since 1990 – worth more than £10 billion.[43] Another inequality is found in the price paid for carbon credits. Within Europe carbon credits have traded as high as 30 Euros per tonne (in

[40] T. Tietenberg, The tradable-permits approach to protecting the commons: lessons for climate change, *Oxford Review of Economic Policy* 19(3), 400–419; K. Halsnaes, Market potential for Kyoto mechanisms – estimation of global market potential for co-operative greenhouse gas emission reduction policies, *Energy Policy* 30(1) (2002) 13–32.

[41] Centre for Science and Environment. *Politics in the Post Kyoto World*, http://www.cseindia.org/programme/geg/briefing_paper1.htm; L. Lohmann, Making and marketing carbon dumps: commodification, calculation and counterfactuals in climate change mitigation, *Science as Culture* 14(3) (2005); L. Lohmann, *Climate Politics after Montreal: Time for a Change*, 2006, http://fpif.org/fpiftxt/3025; A. Agarwal, *Making the Kyoto Protocol Work Ecological and Economic Effectiveness, and Equity in the Climate Regime*, 2006, http://www.cseindia.org/programme/geg/pdf/cse_stat.pdf.

[42] K. Brown and E. Corbera, Exploring equity and sustainable development in the new carbon economy, *Climate Policy* 3 (2003) S41–S56; P. Bond and R. Dada (Eds), *Trouble in the Air: Global Warming and the Privatised Atmosphere*, Durban SA, 2004; H. Bachram, Climate fraud and carbon colonialism: the new trade in greenhouse gases, *Capitalism, Nature, Socialism* 15(4) (2004) 5–20; P.H. May, E. Boyd, F. Veiga and M. Chang, *Local Sustainable Development Effects of Forest Carbon Projects in Brazil and Bolivia*, London, 2004.

[43] Point Carbon. *Russia Could Earn 10 bn USD from Ratifying the Kyoto Protocol*, 2006, http://www.pointcarbon.com/article.php?articleID=2325&categoryID=147.

May 2006) when at the same time a carbon credit in the developing world sold for less than 5 Euros.[44] The rationalities are of financial markets – the carbon credits (Certified Emission Reductions or CERS) are cheaper because investments in the developing world are considered riskier.

The final criticism of carbon trading concerns the way in which it has reduced the material effectiveness of the Kyoto protocol by allowing for excess emission reductions to be traded rather than benefitting the climate.[45] Excess carbon credits – such as those held by Russia – can be sold to those who are unable or unwilling to reduce their domestic emissions; and, moreover, credits can be obtained through projects that might have occurred anyway in the developing world. In both cases, domestic emission reductions are avoided through an exchange of 'hot air' rather than meeting Kyoto targets directly. Based on several modelling studies, I have estimated that Kyoto's flexible mechanisms will leave 450 million metric tonnes more carbon in the atmosphere by 2012 than if emission reductions were made domestically. As a comparison the US non participation in Kyoto has the equivalent effect.

The market solution to climate mitigation was proposed by powerful states who used both discursive and political economic power to modify Kyoto to serve their interests and in doing so set the stage for very modest carbon reductions that did little to reduce the risks of climate change. The market narrative was used to establish a new commodity in carbon reductions that has rapidly become a new form of development investment that some critics see as of questionable value to the poor in the developing world while it has become a new arena for capital investment and speculation.

A new narrative: climate change as an investment opportunity

In Europe, the period since Kyoto came into force in February 2005 has seen an explosion of carbon trading and new investment and employment opportunities. More than $10 billion was traded across all markets in 2005, $30 million in 2006, and $64 billion in 2007.[46] The creation, sale and surveillance of carbon credits require a complex set of new institutions and techniques to ensure the stability of the millions invested in the new carbon economy.

Countries have established carbon bureaucracies to prepare greenhouse gas inventories, certify CDM projects, and administer domestic trading and decarbonisation projects. The international community has established offices for scientific assessment (the IPCC), technical support for the climate regime (SBSTA), prototype carbon finance and trading (the GEF of the World Bank),

[44] World Bank, *State of the Carbon Market*, Washington, 2006.

[45] In a recent book chapter I estimate the material effect of these compromises by calculating the difference between the Toronto commitment and the end result of the Kyoto negotiations showing that rather than the 1.5 Gigaton reduction in emissions proposed in Toronto more than 3 extra Gigatons will have been added to the atmosphere by 2012. See D.M. Liverman, Survival into the future in the face of climate change, in: E. Shuckberg (Ed.), *Survival; the 2006 Darwin Lectures*, Cambridge, 2006. Key papers used in my calculations include B. Hare, *Undermining the Kyoto Protocol: Environmental Effectiveness versus Political Expediency*, 2000, http://archive.greenpeace.org/climate/politics/reports/riia1.pdf; M. Den Elzen and A.P.G. De Moor, *The Bonn Agreement and Marrakesh Accords: an Updated Analysis*, Bilthoven, 2001, http://rivm.openrepository.com/rivm/bitstream/10029/9703/1/728001017.pdf.

[46] The most useful reports on carbon markets include the annual World Bank, State of the Carbon Markets reports (published on line and used here) and subscription services such as Point Carbon (www.pointcarbon.com).

registries for carbon trades, and executive boards to oversee the CDM. Numerous investors, carbon brokers and consultancies are now involved in developing and financing CDM projects, promoting voluntary carbon offsets (commitments made by individuals and corporations outside the climate regime to offset their emissions by investing in carbon mitigation projects at home or abroad), and advising governments and business on trade and investment opportunities. The opportunity to obtain carbon credits through JI and CDM, and the attempts of countries to meet obligations through domestic policies, has stimulated business interests across a range of sectors including renewable and nuclear energy, forestry and biofuels. Corporations such as BP and Toyota are also seeking market advantage by shifting to lower carbon products and by embracing climate protection in their public relations activities.

Thus the market solution to climate change is now locked in not only to international environmental law through the Kyoto Protocol but also into the investment strategies of thousands of companies in the private sector. A triumph of market environmentalism, this narrative will reconfigure international relations and geographies for many years into the future. The trickle down effects of the flexible mechanisms are reshaping local geographies as carbon forestry, hydro and other projects are implemented in communities in the developing world – some with genuine local participation and sustainability criteria, others with little more than cheap carbon credits in mind.

Conclusion

My goal in this paper was to show how three key narratives – dangerous climate change, common but differentiated responsibility, and carbon trading – became part of the international climate conventions and to analyse some of the implications for equity and the environment. I have tried to demonstrate that dangerous climate change is a subjective concept that has become the focus of climate science with inadequate attention to the human and geographical dimensions of climate risks. I have suggested that the narrative of common but differentiated responsibility has been submerged into the raw politics of negotiations about emission reductions with only modest gestures to north–south relations or to the real magnitude of mitigation needed to avoid serious impacts. And I have suggested that carbon trading has become a victory for market environmentalism and neoliberalism – with some negative implications for the climate and many local communities.