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This material was the basis for a Seminar given to the New Zealand Climate Change Research Institute, treating the Kyoto Protocol as a hospital case and concluding with a 'hospital discharge report', now Section 7. Additional material is provided in Section 8 to amplify the Leaky Bucket concept and its possible incorporation into a Copenhagen Initiative that addresses threatened climatic catastrophe.

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UKBRC Working Paper 3:

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1. Introduction

The "**leaky bucket**" is in contrast to the '**silver teaspoon**' of the existing flexibility mechanisms – Joint implementation under Article 6 of the Protocol and the Article 12 Clean Development Mechanism. These mechanisms are so characterized because they are expensive (due to high transactions costs) and (purportedly) watertight, but too small in effect, relative to the scale of the excess stock of carbon in the atmosphere. Indeed a variety of voluntary carbon markets has grown up to meet demand in the community for low carbon or zero carbon goods and services, demand for which is, in turn, far less than is needed to remedy the problem. To shift carbon fast enough to impact on the excess stock, something larger and less costly is needed – a 'bucket', even if a little 'leaky' in the sense of rewarding desirable activity, whether or not 'additional'.

The leaky bucket's core concept is that commitments by Parties to policies and measures that cool the earth in any way should be assessed relative to equivalent fossil fuel emissions reductions and count towards an *ex ante* buy-out of emissions reductions commitments (i.e. increase of allocated amount). In general there would be no carry-through to entities (firms and other agents affected by a Party's policy) of the need to demonstrate a baseline scenario such as is needed for an assessment of that Party's commitments. This is in contrast with the project based flexibility mechanisms that count *post hoc* towards fulfillment of already determined emissions reductions commitments, where project-by-project additionality needs to be demonstrated and where the types of projects that can count is restricted.

The distinction between *ex ante* and *ex post* is to some extent psychological since there is no reason why a Party may not undertake new policies after allocated amounts have been settled, or why it should not, in the course of on-going negotiations, be required to strengthen policies and measures that fail to live up to previously claimed effectiveness. What the distinction is intended to convey is the idea that entities would be unburdened of the transactions costs involved in demonstrating 'additionality' and that Parties would be incentivized to deploy a wider range of policies and measures, involving a wider range of activities, than can be the case under a cap and trade regime.

Here we examine the origins of Kyoto's problem and outline a cure, illustrating its possible implementation through a Copenhagen Initiative (CI) that incorporates the leaky bucket concept. Given the greater cost-effectiveness of the wider range of mitigation activities incentivized by the leaky bucket, Parties participating in such a CI would agree to more ambitious baseline emissions reductions commitments (smaller allocated amounts prior to policy related *ex ante* additions) and yet incur lower compliance costs.

2. Kyoto's problem

There is a growing disconnect between climate science and climate policy, due in part to an underpinning economic analysis which is increasingly irrelevant as the threat of climatic catastrophe becomes recognized to be statistically significant (Weitzman, 2008). The disconnect is apparent from the increasing plausibility of specific threats of climatic catastrophe (Smith et al, 2009; Hansen et al, 2008; Hawkins et al, 2008; Spratt and Sutton, 2008; Witz, 2008; Hearty et al, 2007; Revkin, 2007; Tarko, 2006)

and in the failure of the Kyoto Protocol to prevent increases in the level of greenhouse gases (Helm, 2008), with no demonstrable progress in 2005, as required in the Protocol's Article 3.2, and with greenhouse gas levels rising faster since 2000 than the most pessimistic projections of the IPCC (Raupach et al, 2007). On the application of a plausible metric for danger of climatic catastrophe (Read, 2007) the tipping point (Lenton et al, 2008) for collapse of land base ice cover on Greenland and the West Antarctic Ice Shelf, and other threats, possibly linked (Kreigler et al, 2009) is very unlikely to be avoided by Kyoto style cap and trade alone (Chapter 6, sections 4 and 5). On a precautionary basis, this must be addressed by Biosphere Carbon Stock Management (BCSM) possibly in conjunction with raising cloud albedo (Crutzen, 2007; Salter and Latham, 2008). BCSM involves the build-up of terrestrial carbon stocks through worldwide soil improvement yielding sustainable rural development (Chapter 5). Due to design features of the UNFCCC and of its subordinate Kyoto Protocol, such BCSM and other measures are not incentivized within the current structures, which are accordingly dysfunctional.

However, a basic design fault in the current policy regime, entrenched in the language of the UNFCCC, and hence in the Kyoto Protocol, provides hope that this disconnect can be cured more easily than is widely believed. The design fault effectively limits actions for reducing greenhouse gas levels to a small and high cost subset of all possible actions, leading to resistance to effective policy and to negligible progress.

3. The language of the 1992 Rio Climate Change Convention

The Kyoto Protocol is pursuant to the Berlin Mandate, adopted under Article 4.2(d) of the UNFCCC by its Conference of Parties at its first meeting (COP1) late in 1995. Having reviewed paragraphs 2(a) and (b) of the Convention's Article 4, COP1 agreed that these subparagraphs were not adequate, and to begin a process for enabling it to take appropriate action for the period beyond 2000. This process led to the adoption in 1997 of the Kyoto Protocol, though the consensus procedures of the COP delayed finalization until after 2000, with the Marrakesh accords of 2001. The Kyoto Protocol aimed to strengthen the commitments by developed country Parties in UNFCCC Article 4, to a return to **earlier levels of anthropogenic emissions** of greenhouse gases (Article 4.2(a)) and specifically (but with no target date) **to 1990 levels of these anthropogenic emissions** (Article 4.2(b) – my emphases). Although other language in Art 4 refers to protecting and enhancing greenhouse gas sinks and reservoirs, the emphasized words indicate the priority given to reducing emissions as a means of meeting the ultimate objective.

In following the Berlin Mandate, the Parties aimed to pursue the ultimate objective of the Convention's Article 2 – i.e. to stabilize **greenhouse gas concentrations at a level** that would prevent dangerous anthropogenic interference with the climate system – and to be guided by the Principles set out in its Article 3. Two of these principles (3.1 and 3.3) relate to positive action to protect the climate system and three of them (3.2, 3.4 and 3.5) condition such action, 3.2 by requiring consideration to be given to the needs of developing countries; 3.4 by requiring that policies should be integrated into national development programmes that promote sustainable development; and 3.5 by requiring Parties to cooperate in an open international economic system and proscribing the adoption of climate change policies that restrict international trade. Article 3.1 calls for the developed country and other Parties listed in Annex 1, to take the lead in action to protect the climate system, and Article 3.3 calls for precautionary measure to anticipate the causes of climate change and mitigate its adverse effects.

Note that the emphasized wordings contain two uses of the word **level** that are quite distinct. The concentration of greenhouse gases in the atmosphere constitutes a stock of such gases (with 1 part per million of CO_2 corresponding to approximately 2 billion tons – Gigatons, or Gt. – of carbon, or nearly 8Gt

of CO_2[1], so that current levels, nearing 400ppm, amount to about 800 Gt. of carbon). But anthropogenic emissions constitute a flow, of the order of 6 Gt of carbon per annum related to fossil fuel use and another 2 Gt related to land use – farming and forestry. Confusing these two uses of **level** may have contributed to a misunderstanding that to control anthropogenic emissions is to meet the ultimate objective of the Convention. Or it may simply have been due to a logical fallacy, that to remove a cause will remove its effect.

However, a more potent source of error was implicit in the treatment of greenhouse gases as pollution, i.e. as a contaminant, the concentration of which can only be stabilized by reducing emissions, relying on decay or dispersion to remove these unnatural substances[2]. For such problems, economic theory demonstrates that putting a price on emissions that equalizes the marginal costs of reducing emissions with the marginal cost of damage, is the efficient (least cost) remedy. An example of such atmospheric pollution is CFC, an ozone depleting substance which does not occur naturally, and emissions of which are controlled under the Montreal Protocol, with some prospect of curing the 'ozone hole' by mid century. Ironically, the Montreal Protocol deals effectively with CFC's without recourse to putting a price on CFC emissions.

4. Managing Carbon Stocks

But the main greenhouse gases, water vapor and carbon dioxide, are natural and necessary trace gases in the atmosphere, without which life on earth would cease. The quantity of water vapor is dependent on the average surface temperature of the oceans which, paleo-climatic research shows, is driven mainly by the concentration of CO_2 in the atmosphere[3]. Such concentration is a stock of carbon and thus it is management of stocks of carbon in the atmosphere, in the ocean, and in terrestrial

[1] Since ratification of the Kyoto Protocol, in which emissions of a range of greenhouse gases are quantified in terms of Gg of carbon dioxide equivalent (Giga-grams, with 1 million grams per tonne and 1 billion grams per Gg = 1000 tonnes) it has become conventional to measure the quantity of carbon in the atmosphere in terms of the mass of CO_2 into which the carbon is combined, with 1 Gg of carbon in 44/12, i.e. 3.67 Gg of CO_2. In this paper, which emphasizes the significance of the natural carbon cycle, the earlier custom of quantifying in terms of Gt of carbon is used.

[2] I am grateful to Mick Common for pointing out that I am using "pollution" in the vernacular sense although both environmental scientists and economists define it as any substance, naturally occurring or contaminant, that is present in excess and causing deleterious effects, e.g. "noise pollution". Economists have developed theory related to the optimal management of such stock pollutants where natural assimilative capacity removes from the stock and economic activity that causes emissions adds to it. In these models, economic activity is treated as a policy variable but assimilative capacity (possibly variable) is taken as given by the laws of nature. Thus, whether policy has been informed by simplistic versions of pollution economics or by the more sophisticated stock pollution models, the vision is of managing such stocks by controlling emissions, and the language relating to commitments for action in the Climate Convention and Kyoto Protocol is worded accordingly, even though farming and forestry, both economic activities strongly influenced by policy, manifestly affect assimilative capacity.

[3] Studies suggest that a warming phase out of deep glaciation is initiated by Milankovic cycles in the intensity of solar radiation that are due to variations in the earth's orbit. But the release of CO_2 from melting ice and warming oceans provides a greenhouse effect, setting up a positive feedback with more melting and more CO_2 in the atmosphere causing more warming, a process that is moderated by the absorption of atmospheric carbon into the biosphere as warmer climes and increased availability of carbon in atmosphere stimulates an increased stock of carbon in the plants and animals that make up terrestrial biomass. A cooling phase, back into glaciation from a warm earth, begins with a reduction in radiation from the Milankovitch warm peak that initiates cooling, with positive feedback in the cooling process due to increased CO_2 absorption into the cooling oceans and into the snowfall that begins the re-accumulation of polar ice, with consequently reducing greenhouse effect and further cooling. Note that paleo-climatic glaciation cycles were associated with changes in ocean levels of over 100 meters, even one tenth of which would be catastrophic for a civilization that supports a population of several billions, many living in fertile low-lying areas close to the sea. These changes occurred in several jumps of a few meters over a decade or so, corresponding to the collapse of ice sheets, or parts of them, into the ocean

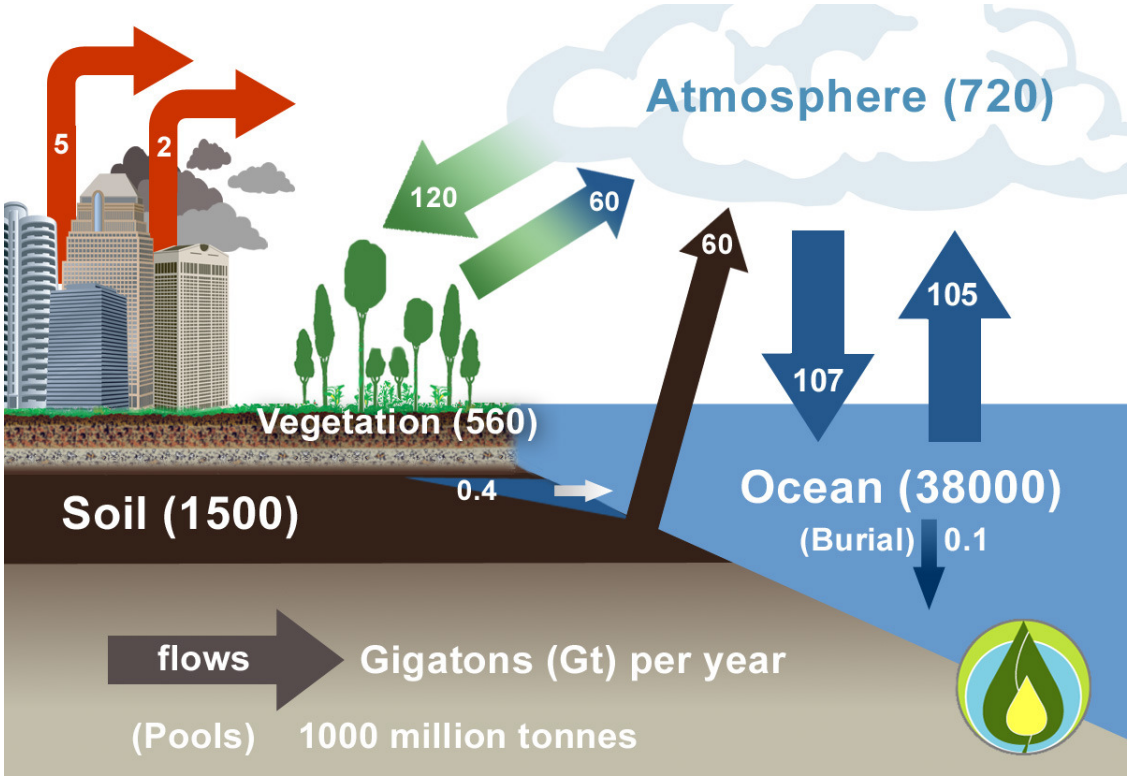
storages, rather than relying simply on a reduction in the anthropogenic flow of carbon into the atmosphere, that provides hope of an effective response to the UNFCCC's Article 2 ultimate objective.

That such carbon stock management could provide an effective response is evident from Figure 1 from which it can be seen that net annual fixation of ~60 Gt (~120 Gt absorbed minus 60 Gt re-emitted through the respiration that meets the energy requirements of the plants themselves) and the balancing ~60Gt annual decay and oxidization of biomass from soils back to atmospheric CO_2 and water, are each of the order of ten times as great as fossil fuel emissions. Thus biosphere carbon stock management (BCSM) that enhances fixation by 10 percent, and that prevents decay by 10 per cent, is twice as effective as reducing fossil fuel emissions to zero.

Such success with Kyoto-style cap and trade is, of course, deeply implausible – at least in the next few decades that are of growing concern as regards the threat of climatic catastrophe and the intensifying science/policy disconnect. Indeed, as shown elsewhere, the ineffectiveness of even such implausible success with emissions reductions means that emissions reductions alone cannot limit the threat of climatic catastrophe – possibly imminent catastrophe.

Providing such enhancement and prevention – growing more trees and crops and processing the resulting biomass into long lived products – is done sustainably, it yields by-product renewable supplies of biomass as fuel raw material that can substitute for fossil fuels and thus enable more ambitions emissions reduction targets to be achieved under Kyoto style cap and trade. Moreover, such a BCSM approach avoids some of the geopolitical problems that arise from extending the coverage of cap and trade beyond the scope and timing determined by the developed countries that have agreed to participate in the Kyoto Protocol's first commitment period, 2008-2012 inclusive.

Figure 1*. Stocks (pools) and flows of carbon between atmosphere, ocean and land



Thus, instead of imposing a converge and contract regime on unwilling developing countries – that see a threat to their sustainable development, contrary to UNFCCC Article 3.4, and which do not accept they have historic responsibility for the current dangerous accumulation of carbon in the atmosphere – BCSM relies on gains from a trade that is already stimulated by 'peak oil' and dwindling fossil fuel supplies, and increasingly needing to be conditioned by sustainability constraints. This can yield sustainable economic development for many impoverished but land-rich and climatically blessed developing countries, based on exporting carbon credits and sustainably produced biofuel supplies to industrialized countries located mainly at higher latitudes, where growing conditions are less favourable.

5. Political aspects

Rational though it may be to address the excess stock of carbon in the atmosphere by such management of the terrestrial biosphere, prospects are bleak for early recognition by the COP that the pollution model, implicit in the emissions reductions approach of UNFCCC Article 4, is incomplete – *a fortiori* COP consensus in accepting that emissions reductions alone cannot work. For the pollution model feeds a scapegoating psychology that, building on the logical fallacy noted previously, seeks to blame energy big-business for the accumulation of carbon in the atmosphere and to impose high cost emissions reductions on the energy sector. Or, alternatively, a guilt-tripping mentality that sees past consumption habits as the root cause and which, through creating a climate of opinion that accepts the 'no gain without pain' dictum, leads to the same high cost approach.

Either of these, as well as the deep suspicion of the G77 and China group of developing countries, that the Annex 1 Parties seek always to avoid their differentiated responsibility under Article 3.1, may influence individual Parties to resist the paradigm shift that is needed. And resistance by individual Parties is sufficient to impede progress, given the consensus procedures of the COP[4]. Even without these problems, difficulties in adopting a new paradigm would arise from the path-dependant nature of a negotiating process. The last thing that any negotiator wants is to re-open the can of worms which they hoped was closed by the previous round of negotiations. So earlier mistakes, *a fortiori* the basic error in treating CO_2 as pollution, are not easily got onto the negotiating table.

Of course there are other problems with the Kyoto Protocol that have been discussed, such as incomplete geographical coverage, the focus on production rather than consumption, and the lack of incentive for investments yielding emissions reductions over more than the five year span of the initial commitment period. These can be remedied within a framework that addresses the basic conceptual error. But drawing attention to that basic error is a little like the small boy in the fairy story who notices that the emperor has no clothes on. For there has grown up a substantial vested interest in the emissions reductions paradigm, in terms of the UNFCC bureaucracy in Bonn that operates the mechanics of the Kyoto Protocol; of the growing army of consultants and carbon accountants that are involved in national carbon accounting and in the complexities of the flexibility mechanisms – Joint Implementation and the Clean Development Mechanism – especially as regards demonstrating 'additionality'; of those operating various carbon markets both official and voluntary; and of the various NGO's and analysts that

[4] Article 7.3 of the UNFCCC commits the first meeting of the COP to adopt rules of procedure, including decision-making procedures, but has never been implemented. So the COP progresses through consensus, essentially a convoy moving at the speed of the slowest ship – which is very slow in the case of some Mid-East oil-producing countries that, advised by think tanks funded by the US coal industry, both cast doubt on the science of anthropogenic interference with the climate system and also insist on full scientific certainty as the necessary basis for action.

have fed on the process. Not that there would be no need for markets under a BCSM regime, just that the focus would different and the price of carbon lower

6. Article 3.3 of the Convention

Despite these bleak prospects, however, Article 3.3 has additional wording that provides a framework for BCSM action (and other potentially effective actions, such as easily reversible cloud albedo modification (Crutzen, 2006; Latham and Salter, 2006) parallel to a continuation of the cap and trade regime. And, as suggested above, such a framework would be complementary to continued cap and trade through enabling more ambitious emissions reductions commitments to be made (setting aside the concern over the realism of commitments to outcomes that is discussed below). For, as well as calling for precautionary measures, Article 3.3 continues:

> " Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost."

Several points are to be noted. Firstly, there is no reference to the Conference of Parties so that action by individual Parties or partnerships of Parties cannot be impeded by a lack of consensus in the COP. Bilateral and group-lateral partnerships (e.g. through the G8 Global Bioenergy Partnership) have been proposed, along with suggestions as to how such actions can link with a continued cap and trade regime (expanded in Section 8 below). Secondly, lack of full scientific certainty regarding a threat, or regarding the efficacy of proposed measures, should not impede action. In an uncertain world, Parties should take what action seems best, rather than allow the threat to grow unabated. And thirdly, action should be cost effective, ruling out the cost-enhancing aspects of the Kyoto Protocol, such as its neglect of potential gains from trade in the management of carbon stocks, and through its focus on low-emissions and zero-emissions technologies that are high cost, rather than taking the wider-ranging holistic greenhouse gas management approach.

7. A way ahead

The dysfunctional organization of current climate change mitigation efforts arises from a basic error in the conceptual approach that underpins the main thrust of the Kyoto Protocol, and of Article 4 of the UNFCCC which provides its legal foundation. This derives from treating CO_2 as contaminating pollution. This conceptual error is unlikely of remedy by the Conference of Parties, given that body's continuing failure to adopt rules of procedure. However, the wording of Article 3.3 of the Convention provides a legal framework for – indeed imposes a duty on – Parties, individually or in groups, that perceive a threat of serious or irreversible damage, to take cost-effective action.

Such a threat exists, to the required burden of proof under Article 3.3, in relation to the potential collapse of land based ice masses on Greenland and West Antarctica. The prospects of its effective mitigation under Article 4 emissions reductions are negligible. However, parallel action under Article 3.3 by a substantial group of like-minded Parties –possibly as a 'Copenhagen Initiative' – that is complementary to continued cap and trade action under Article 4 (i.e. that enables more ambitious emissions reductions commitments) as well as supplementary (i.e. facilitates a wider range of earth cooling activities) can point the way to a worldwide biosphere carbon stock management (BCSM) regime in addition to facilitating other ways of cooling the planet that are unrelated to greenhouse gases. This offers a win-win-win prospect of limiting the threat of climatic catastrophe; of facilitating ambitious emissions reductions commitments post 2012 – maybe, if done quickly, even meeting the 2008-2012

commitments – and of delivering sustainable rural development along with environmental benefits to many impoverished developing countries

8. A Copenhagen Initiative (CI)

How, then, can such a response to threatened catastrophe be implemented through an initiative based on Article 3.3? It is assumed that such an initiative will be undertaken by a subset of Parties to the Convention that recognizes the threat. These may comprise a single large group or a number of bilateral or group-lateral sustainable bioenergy partnerships. For pursuing its aim the CI will need to operate a parallel process to that involved in continued cap and trade and it may be hoped that the two processes, and the personnel involved, will maintain mutual respect and collaboration. However, it may be noted that the consensus procedures of the Conference of Parties, which have so far been used to obstruct effective action, can be turned to opposite advantage. While it may be hoped that a confrontational situation will not arise, an influential group of Parties that recognize the threat of dangerous or irreversible climate change can simply obstruct agreement post 2012 until parallel actions in response to that threat are given due weight in the post-2012 regime. With that understanding of the hoped for collaborative relationship, it remains to discuss the *modus operandi* for the Parties to such a Copenhagen Initiative

8.1 Extending the scope of mitigation policy

There is a range of activities that can serve to cool the planet which have been classified (Lenton and Vaughan, 2008) into two types – reducing reception of incoming solar radiation (by raising the albedo, or whiteness of the earth as seen from the sun) and increasing outgoing radiation into outer space (by thinning the blanket of greenhouse gases that impedes the transmission of infra-red radiation from the earth's surface). For meeting the ultimate objective of the Climate Change Convention's Article 2, there is no a priori scientific reason for preferring any of these activities – the first type raises the level of greenhouse gases that is safe, the second lowers that level towards what is safe. From other perspectives – e.g. addressing the threat to ecosystems from ocean acidity – the second is clearly preferable. Of the second type there are two options, reducing emissions into the atmosphere and increasing removals.

However, as matters stand, only reducing emissions receives unequivocal support under the Kyoto Protocol, so that a wide range of activities for addressing climate change remain unimplemented up to the present, raising the cost of achieving any specific cooling of the earth and making some cooling levels unattainable. These include black carbon reductions (possibly the only way to save the Himalayan glaciers); cloud albedo enhancement at low level over the oceans (possibly the only way to save coral ecosystems); and at high level in polar regions (possibly the only way to save Arctic sea ice); and the variety of ways of managing carbon stocks, including long term investments in, for instance, irrigation schemes (together, possibly the only way of saving threatened land based ice masses on Greenland and West Antarctica).

The objective of the additional structures involved in a Copenhagen Initiative (CI) is, then, to provide incentives for the full range of acceptable cost-effective mitigation technologies that need to be deployed in the face of threatened climatic catastrophe. Here acceptable means those technologies that are sufficiently cost effective and low risk to be adopted under the CI on the basis of expert advice.

8.2 Expert negotiations

There is a central role for expert judgment over several of the factors involved both in assessing cost effectiveness and in determining which activities are acceptably low risk. A possible approach for the Parties to the CI is to enlist such expert judgment is through emulating the model advocated by Schelling (1992) based on the negotiations over the distribution of Marshall Aid post World War 2. Although an element of bargaining is intrinsic to the negotiation process, it was narrowed down through expert analyses presented by the negotiating Parties. These were subjected to the peer-review of the participating experts so that, with experience, trust and understanding of each others' positions developed, so that the horse trading needed to clinch agreement was narrowed down and confidence secured in the fairness of the outcome.

On that model, a CI Party seeking to cool the earth by reducing black carbon – for instance by funding Dhaka City to replace its two-stroke motorized rickshaws with battery-electric substitutes – would come to the negotiating table with details of its policy proposal and its anticipated cooling impact. After review, this would be accepted (or not) up to an agreed cooling impact that would be pro-rated down, on account of uncertainty, relative to achievement of the same cooling by less uncertain fossil fuel emissions reductions. This agreed cooling impact would then be translated into CO_2 emissions equivalents and be added to the Party's allocated amount under whatever form of cap and trade exists in the post-2012 regime – or indeed pre-2012, under the Kyoto Protocol's existing cap and trade scheme, given any willingness to raise its effectiveness as soon may be, and accordingly to set up the machinery for implementing CI by, say, end 2010 at COP16.

Observing such negotiations, which would be ongoing with, say, monthly meetings, would be the various non-governmental organizations – environmental, business and research/academic – that currently attend Conferences of the Parties, subject to a requirement that they be sufficiently expert to understand the technicalities involved and adequately funded to attend meetings on a regular basis. Without such involvement the appearance would be of a technocratic inter-governmental 'fix'. Part of the process would be regular briefings of the NGO observers and responsiveness to their feedback, possibly through additional work by the IPCC, in which many of the negotiating experts would no doubt also be involved.

Cost effectiveness needs to be measured in terms a common metric for cooling the planet relative to a standardized emissions reduction performance – say the cooling impact that results from an emissions reduction of 1 tonne of Carbon in the current year. Such a metric is dependant on the baseline scenario relative to which the standardized emissions reduction is achieved and the time period over which the cooling is measured, leading to an aggregate impact measured in Watts per square meter times the area affected in square meters times the duration in seconds, giving a dimensionality of Watt-seconds or Joules, or likely Exajoules (EJ – quintillions of Joules) for practical purposes.

The time period would be a matter of expert judgment of the interval over which a tipping point for dangerous climate change could be reached. The baseline would be an updated projection of greenhouse gas levels estimated from the latest records, such as in Raupach et al (2008), and taking account of projected aggregate mitigation achievement from policies and measures in place or committed to by the Parties.

Commitments to outcomes would not be relevant since such commitments are beyond the control of the Parties that make them, being dependant on economic fluctuations amongst several other factors, and, given that the Parties are well aware of this, are token of insincerity, as noted by Schelling (1992) – target outcomes yes, commitments to outcomes no. Then expert opinion can review whether the aggregate of policies and measures by all the CI Parties is adequate for security from the threat of severe

or irreversible danger (given advancing scientific understanding), as well as whether the policies and measures of individual CI Parties are working in the manner claimed. The outcome from these reviews would be calls for changes in the agreed aggregate earth cooling that is needed and for changes in the policies and measures adopted by individual Parties.

Acceptable risk needs to be assessed against the risks from doing nothing more than reduce emissions under a continuing emissions reduction regime. Recent studies by Kreigler et al (2009) reflect the highly abstruse nature of such risk assessment and (to summarise very crudely) lead to the conclusion that there is a greater than evens chance of inducing climatic catastrophe under business as usual scenarios and, even with policy that limits temperature increases to around 3 degrees Celsius, a one in six chance. Climatic catastrophe is here taken to mean triggering one or more of the earth system responses that were categorized as 'reasons for concern' in the 'burning embers' diagram of the 2001 IPPC Third Assessment Report (Smith *et al*, 2009). Here is not the place to comment on these results, rather is the intent to show the need for direct expert input into the risk assessment process.

8.3 Contrasts with cap and trade

Reversibility and permanence are linked questions which raise a general point on risk assessment that is related also to the potential role of sequential decision taking. Clearly, the risks associated with a mitigating activity are qualitatively different if it can be halted and/or undone by later policy decisions. Thus commitment to most mitigating activities, including emissions reductions, is not permanent. But coal left in the ground for policy reasons will be mined if policy is relaxed; aerosols in the atmosphere disappear in a matter of weeks if activity to inject them ceases; forest plantations can be burned off nearly as quickly if such carbon storage is found to be unwise; CO_2 stored deep underground can likely be released; and so on. (However, biochar, once put in the soil would be hard to remove, though it is hard to see why anyone should want to).

The point being made is that the argument of impermanence sometimes leveled at activity other than fossil fuel emissions reductions lacks merit – nothing is permanent and the permanence of any activity brought about by policy, or prevented by it, is no more or less permanent than the policy. We cannot legislate away the freedom of future generations to legislate for themselves, although failure to take some mitigation actions now can remove future policy options – if we fail to create a stock of biomass in new forest plantations, the option of using it as raw material for future biofuel production is not available. But, in general, future decisions will be made on the basis of further research and in the light of experience – e.g. experience of how secure is storage of CO_2 deep underground or research into possible remote climatic responses to actions in particular regions. For instance, we do not need to know whether seeding polar clouds with aerosols will put the Indian summer monsoon at risk before finding out if the technology will work, though its large scale deployment should, in a sequential decision making process, await the outcome of efforts to model such tele-climatic effects.

Relaxation of emissions reductions commitments as a consequence of a broadening of the range of mitigating activities that is incentivized by policy is a concern that would certainly be expressed by environmental NGO's. The words "and be added to the Party's allocated amount" used above will raise alarm bells amongst those who are concerned there should be no easy way out from the commitments to emissions reductions under Kyoto or its post-2012 successor. Firstly it may be noted that, if CO_2 really were contaminating pollution, that position would be correct. And that it has taken so long for the basic error, noted in Sections 4 and 5 above, to have been brought to attention means that it is hardly surprising if such NGO's – and others mentioned in Section 4 above – find it difficult to emerge from the emissions reductions mindset. However, the reality that emissions reductions alone cannot remove the

threat of climatic catastrophe should lead to a reappraisal of that position, which may be helped by understanding that the objective of the CI is to facilitate much more ambitious emissions reductions than can conceivably be negotiated without it.

Thus the agreed allocated amounts, to which the cooling impact of policies and measures, translated into CO_2 emissions equivalents as described above, is added, would be smaller, possibly much smaller, for Parties participating in the CI than they could accept without the CI.

Nor is BCSM an easy way out from the hard choices that confront humanity in dealing with the excess stock of greenhouse gases although it does deliver a more attractive outcome than seems possible with emissions reduction alone, even if that were an effective response to the threat of climatic catastrophe. For, BCSM will, gaining from experience with land use improvement schemes financed ultimately by the energy consumer, deliver on several of the multilateral environmental agreements in addition to the Climate Change Convention. In the vision of the Sustainable Biofuels Consensus it can deliver "***a landscape that provides food, fodder, fibre, and fuel, that offers opportunities for rural development; that diversifies energy supply, restores ecosystems, protects biodiversity, sequesters carbon; and that contributes to global peace"***. That requires sound policy and hard work, including a major capacity building effort to create a corps of grassroots entrepreneurs trained to develop community based country driven BCSM projects over the decades ahead. It is not a relaxation of effort to cool the earth but of the artificial constraint on how to do it embodied in Article 4 of the Convention.

Additionality is intrinsic to the project based flexibility mechanisms of the Kyoto Protocol and leads to the high transactions costs that are one of the reasons for the disconnect between science and policy to which the CI would be addressed. Additionality, demonstrating that a particular project results in measurable emissions reductions additional to the reductions that would occur anyway, is a construct from academic cost-benefit analysis, with little relevance to practical activity in the real world.

Its application requires the construction of a hypothetical scenario that is counter factual to how events turn out once the project is in place. Then costs and benefits are calculated with the project in place (how things turn out in the real world) and without the project (how things would have turned out without the project). The difference between the two then provides the theoretical basis for calculating the costs and benefits of a project. Under the additionality principle, a project only attracts carbon credits if it would not have gone ahead without such credits – i.e. if the existence of the credits caused a project to be profitable that would not have been profitable without the credits.

Now, while that concept is central to theoretical cost-benefit analysis, and to desk studies that aim to determine whether a project (such as the third London Airport) should go ahead, it does not carry over into the real world, where it simply generates incentives for deceit. For instance the Civil Aviation Authority does not ask passengers whether they would have flown anyway had the Airport not been there, or attempt to charge the additional passengers (marginal passengers in economists' jargon) more (or less). For all the passengers would obviously have an incentive to pretend they would (or would not) have flown and then the CAA would need to set up systems to detect whether the passengers were telling the truth, and an army of consultants develop to advise passengers how to answer the CAA's questions, and so on and so on.

Thus it is with the flexibility mechanisms, with bureaucrats and consultants galore focused not on making projects that cool the earth happen, but on denying or asserting credit for projects on the grounds that they would or would not have happened anyway. Essentially, in the highly uncertain future of, for instance oil prices, consultants must demonstrate profitability with the carbon credit and loss without the carbon credit. To practical business people, and to shrewd inhabitants of the land alike, there are rich pickings from strategic behaviour and collusion.

So, under the CI, a Party's policies and measures for incentivizing best practice earth-cooling activities would be assessed *ex ante* by the expert negotiators as to their likely impact relative to an appropriate baseline, and buy out of additional allocated amounts – say for biochar soil improvement in the Sahel – be awarded to the Party or Parties involved accordingly.

But there would not be discrimination for particular projects based on whether the benefits of the project are greater than the costs with or without the incentives created by the policy: agents in the field – land owners, village communities, energy firms, agricultural cooperatives, etc. – would simply act in response to the policy incentives without having to prove what they would have done without them. They would merely need to demonstrate [[due diligence in the]] best practice in performing whatever activity the policy aims to promote

Measurement difficulties provide the most valid explanation for the barriers to take-up of biotic carbon stock management activities under the flexibility mechanisms. Fossil fuel emissions are easily measured because of the existence of detailed and consistent international statistics and energy balances assembled by the United Nations and the International Energy Agency. These are based on national statistics aggregated from commercial accounts that are very accurate, in order to meet normal book-keeping requirements. Thus a reduction in emissions, though difficult to achieve (i.e. costly) and therefore small for a given carbon price, can be measured with accuracy.

In contrast, biotic carbon stock changes are relatively large for a given carbon price but difficult to measure accurately owing to their inherent uncertainty (given variability in the weather, pests, etc. and given the lack of a market, and hence of accountancy, for the residues from food and fibre production where much of the readily usable biotic carbon stock resides). So hard-won fossil fuel emissions reductions by one Party of say 1 million tons of CO_2, plus or minus 2 per cent due to a carbon price of $10 per ton cannot easily be related to, say, a soil carbon offset by another Party of 5 million tons, plus or minus 2 million tons, resulting from the same price on carbon. The first Party would want to be very sure that its own efforts to reduce CO2 levels by costly emissions reductions were not going to be undermined by the second Party's claimed but hard to verify soil carbon increase. As a consequence only a very limited range of biotic activity – afforestation minus deforestation plus reforestation – is fully recognized in the Kyoto Protocol's Article 3.3 and the measurement and monitoring aspects are so onerous that very few such projects have gone ahead. Other biotic carbon sinks may also be adopted voluntarily by Parties under the Protocol's Article 3.4 but the uncertainties are so great that these have not been taken up.

9 Conclusion

The policy responses of the Parties to the Climate Change Convention's Article 4 commitments, and to its subordinate Kyoto Protocol, are manifestly failing to advance the Convention's Article 2 ultimate objective of avoiding dangerous anthropogenic interference with the climate. Thus there is a growing disconnect between climate science and climate policy. In part this is due to the limitation imposed on policy responses by the concept of emissions reductions embodied in Article 4. This restriction raises the costs of response and thus raises industry resistance and inhibits action, with widespread failure to meet commitments now likely unless prolonged economic downturn greatly reduces fossil fuel use. However, additional actions in response to the threat of severe or irreversible damage are sanctioned by Article 3.3 of the Convention and could be taken through a parallel process, possibly embodied in a Copenhagen Initiative undertaken by a group of Parties that recognize such a threat.

Such a parallel process would be designed to incentivize a range of climate cooling activities that do not fall within the emissions reduction paradigm of Article 4. These would include the biosphere carbon stock management (BCSM) concept. The proposed 'leaky bucket' is designed as a framework for BCSM actions that are inhibited by the measurement and monitoring requirements of the flexibility mechanisms of the Kyoto Protocol. Such BCSM actions, on the scale needed to address the threat of climatic catastrophe raise environmental and socio-economic concerns that need to be addressed and are covered in a forthcoming book.

Of course such a CI process could be undertaken by a group of Parties at any time, simply abandoning hope of UN agreement on effective action and allowing other Parties to the, by then effectively defunct, Climate Convention to free ride on their efforts. Why, then, should such other Parties implicitly participate in a Copenhagen Initiative by agreeing that the CI should be recognized as a building block in the structure supported by the UN Framework Convention on Climate Change? Firstly, because, despite the uncertainties involved, the CI Parties would be doing more than otherwise to mitigate climatic threats; secondly because of the scientific reality that many earth cooling activities exist which cannot be covered by cap and trade (or by carbon taxing) due to measurement aspects; thirdly because the CI does not demand burden sharing but promises sustainable development for many countries, driven by industrialized country investment in land improvements yielding carbon credits and sustainable biofuel exports; and, perhaps most importantly, because of the commitment to internationalism evident in membership of the United Nations.

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