Nested Externalities and Polycentric Institutions: Must We Wait for Global Solutions to Climate Change Before Taking Actions at Other Scales?

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1 Introduction

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007) and the Stern Report (Stern 2007) both stress the need to recognize the impact of human actions on the global environment. Even though there is now a relatively high level of agreement among scientists about the danger that humans are facing related to the uncorrected negative externalities of greenhouse gas emissions (Rezai et al. 2010), little agreement exists about what should and could be done (Dutta and Radner 2010; Schelling 2007). Further, agreement among citizens concerning the seriousness of global warming is falling. In the March 2010 Gallup Poll on the Environment, 48 % of those surveyed responded that the seriousness of global warming was generally exaggerated—a 13 % increase as contrasted with poll results in 2008 (Newport 2010).

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The Kyoto Protocol to the United Nations Framework Convention on Climate Change is an international environmental treaty created and signed at the Conference of the Parties of the UNFCC in Kyoto in 1997. More than 180 countries have now ratified the protocol, but the United States has not. Considerable disagreements exist even among the major states that have signed regarding how large a reduction in emissions should be imposed (Matthews and Caldeira 2008). Major debates exist over a number of issues related to achieving efficient and equitable mechanisms at a global level. One issue relates to who is responsible for the current and immediate future levels of CO_2 in the atmosphere (Botsen et al. 2008; Dellink et al. 2009; den Elzen et al. 2005; Lauwers 2010; Lecocq and Hourcade 2010). In other words, who should bear the primary burden of paying for solutions? (Chichilnisky and Heal 1994, 2000; Baer et al. 2000; Posner and Sunstein 2008). Other debates address whether taxes or quotas are the best instrument for achieving abatement (Karp and Zhang 2010). Similar scholarly concerns have also been raised regarding claims that Payments for Ecosystem Services (PES) can increase carbon sequestration while at the same time enhancing species conservation on the same landscape (Nelson et al. 2008).

Given the failure to reach agreement at the international level on efficient, fair, and enforceable reductions of greenhouse gas emissions, continuing to wait without investing in efforts at multiple scales may defeat the possibilities of significant abatements and mitigations in enough time to prevent tragic disasters. We need to make a scholarly investment in a more appropriate theory of global change that offers a better explanation of micro-level incentives and outcomes (Chipman and Tian 2010; Chichilnisky 2010; Asheim et al. 2010) as well as being a foundation for more effective public policies. This paper represents an effort to posit a theory of nested externalities at multiple scales to provide a better foundation for analyzing the multiple scales involved in reducing the threat of climate change. Another goal is to balance the arguments made in the policy literature that a global solution is the *only* way to cope with climate change. "Global solutions" negotiated at a global level—if not backed up by a variety of efforts at national, regional, and local levels—are not guaranteed to work effectively.

The problem of averting massive climate change is a global "public good" (Chichilnisky and Heal 2000; Sandler 2004). Millions of actors affect the global atmosphere and they all benefit from reduced greenhouse gas emissions. The problem is they benefit whether or not they pay any of the costs since beneficiaries cannot be excluded. Trying to solve the problem of providing a public good is a classic collective-action dilemma (Cole 2008). It is probably the largest dilemma the world has ever knowingly faced. Many analysts call for an institutional solution at the global level (see Stavins 1997; C. Miller 2004; Wiener 2007).

Given the widespread presumption that any collective-action problem that has global effects must be "solved" entirely at the global level, several theoretical questions need to be addressed as analysts undertake the next round of research on climate change. They include:

1. How may polycentric institutions improve exclusive reliance on a global approach to cope with global climate issues?
2. Are multiple, nested externalities produced by decisions made at less than a global scale?
3. What types of actions are being taken at less-than-global scale to reduce greenhouse gas emissions?
4. Are large-scale governments usually better equipped to cope with collective-action problems that have outcomes that are large scale themselves?
5. If multiple governments and other organizations work to reduce energy consumption and greenhouse gas emissions, does that only produce leakage, chaotic systems, and potentially counterproductive processes?

Each of these questions will be theoretically and empirically addressed below.

2 A Polycentric Approach

Let us briefly review the origin of the term "polycentricity." During the 1950s, massive academic criticism was leveled at metropolitan areas across the United States and Europe due to the large number of small-, medium-, and large-scale governmental units operating at the same time. Scholars thought this was chaotic. Vincent Ostrom et al, Charles Tiebout, and Robert Warren wrote a classic article in (1961) entitled "The Organization of Government in Metropolitan Areas: A Theoretical Inquiry." The authors reasoned that a simple dichotomy between "the" market and "the" government was not a good scientific approach to the study of public economies. Further, "the" market is not a single unit. It is composed of many small-, medium-, and large-scale firms. The expected efficiency of a market disappears if it were consolidated into a monopoly. There is no reason to presume that a monopoly government is more efficient than a system of governmental units at multiple scales.

Economic theory teaches us about the dangers of allocating all capabilities to a single unit even though one cannot apply *all* lessons derived from the analysis of market economies to the public sector (Williamson 1975, 1985, 2000). Ostrom (1999: 57) referred to a polycentric system as "one where many elements are capable of making mutual adjustments for ordering their relationships with one another within a general system of rules where each element acts with independence of other elements" (see also Ostrom 2008a, b; McGinnis 1999a, b, 2000). A polycentric system exists when multiple public and private organizations at multiple scales jointly affect collective benefits and costs. The early theoretical work on polycentricity stimulated intensive research on the governance of one of the major public goods for urban areas—that of providing public safety (Ostrom et al. 1978)—and is a foundation for the theory presented herein.

Readers of this article may ask: What is the relevance of polycentric systems for the analysis of *global* public goods? The initial relevance of the polycentric

approach is the parallel between the earlier theoretical presumption that *only* the largest scale was relevant for the provision and production of public goods for metropolitan areas, and the contemporary presumption that *only* the global scale is relevant for policies related to climate change. Extensive empirical research found that while large-scale units were an essential part of effective governance of metropolitan areas, small- and medium-scale units were also *necessary* components (Parks and Ostrom 1999). An important lesson is that relying entirely on international efforts to solve global climate problems needs to be rethought.

3 Do Nested, Positive Externalities Exist at Multiple Levels from Reducing Emissions?

Greenhouse gas emissions are the result of many actions taken at multiple scales. The positive externalities of reduced greenhouse gas emissions are also distributed across scales—from the household to the globe. Nested externalities occur when actions taken within one decision-making unit simultaneously generate costs or benefits for other units organized at different scales.

Decisions within a household as to what form of transportation to use for various purposes, what car to purchase, what investments to make regarding power consumption within their home, all have small effects on the global atmosphere and relatively larger effects at a smaller scale. Better health is enhanced by members of a household who bike to work rather than driving. Family expenditures allocated to heating and electricity may be reduced when investments have been made in better construction of a building, reconstruction of existing buildings, investment in solar panels, and many other investments in equipment that families as well as private firms can make that pay off in the long run. Similar decisions within firms are also important as buildings used by government offices, businesses, and as private homes account for "more than 70 % of the electricity used and almost 40 % of greenhouse gas emissions in the United States" (Fuller et al. 2009).

No change at a small scale can be expected without shared knowledge about the costs and benefits of actions and shifts in preference functions to take into account previously unrecognized benefits for self as well as others. As the scientific community has achieved a higher level of agreement about human impacts on the global atmosphere, knowledge of the effects of individual and family actions is becoming more available.[1] In local discussions and meetings, information is generated about the prevailing unrecognized costs of individual and family activities. Discussions within the family and with neighbors in a community about actions that can be

[1]Many Web pages are now available for households and businesses to learn about new ways of saving energy. See, for example, the stories about ways to save energy in homes on the Environmental Defense Fund Web pages at http://www.fightglobalwarming.com/page.cfm?tagID=262 (accessed 20 February 2009).

taken to reduce greenhouse gas emissions are also important factors leading to the potential for change (see, for example, Miller 2009). Even without major taxes imposed on energy at a national level, however, families who decide to invest in better insulation, more efficient furnaces and other appliances, to join a carpool whenever feasible, and other energy-reducing actions, can save funds over the long run as well as reducing emissions. They may face high up-front investments to achieve some of these benefits, but the important point is that positive benefits can be achieved that offset costs at a household or neighborhood level.

Jurisdictions that have established power networks that enable households to invest in solar power to be used for household energy production, and when not needed is contributed to the network, can also potentially reduce local energy costs by working out complex network arrangements as well as reducing greenhouse gas emissions. In Japan, for example, the Ministry of Trade and Industry issued "A New Purchase System for Solar Power-Generated Electricity" that requires electric utilities to purchase solar power electricity that exceeds the needs of households. The national government also subsidizes households that install solar energy. As a result, sales of solar panels rose by 21 % during 2009—the highest level since 1981 (Sato 2010). Investments in better waste disposal facilities and to reduce pollution levels also generate local benefits as well as helping on global emissions. Given that many of the actions generating greenhouse gas emissions are taken at multiple scales, activities to reduce emissions can also be organized at multiple scales ranging from households to the globe (Kates and Wilbanks 2003).

4 What Efforts to Reduce Greenhouse Gas Emissions Now Occur at Less Than a Global Scale?

It is not possible to list the large number of projects going on across the world at multiple scales. What I will do is focus on some of the projects that have been organized at a local level as part of the Clean Development Mechanism of the Kyoto Protocol, at the level of a state government in the United States, at a regional level, and discuss some of the efforts in Europe to substantially reduce emissions. Schreurs (2008) and Hoffman and Eidelman (2009) have identified a large number of experiments at multiple levels that reflect action by diverse governance arrangements to take climate change seriously and take actions to reduce the threat.

4.1 Local-Level Projects and Alliances to Reduce Local-Level Externalities

One of the most successful efforts made by local governments across the United States, and supported by the U.S. Clean Air Act, has been to reduce the level of

fine-particulate air pollution (which in some cases has also reduced greenhouse gas emissions as well). Pope et al. (2009) have completed a major study of the level of the impact on life expectancy of particulate matter in the air sampled over the period from 1979 to 2000 for 51 metropolitan areas (including more than 200 counties). Metropolitan areas across the nation have reduced air pollution levels by one-third. They also found that increased life expectancy during this period was associated with reductions in fine-particulate air pollution after controlling for socioeconomic, demographic, and other variables associated with life expectancy. Given their statistical analysis, the average life expectation that could be attributed to reduction in air pollutants was one-third of a year.

"Buildings use 40 % of the primary energy supplied in the United States, and more than 70 % of all generated electricity, primarily for heating, cooling, and lighting" (Gershenfeld et al. 2010: 1086). Dietz et al. (2009) have identified seventeen actions that can be taken within a home or a business facility that can cumulatively have a major impact on carbon emissions. Thus, retrofitting buildings to add insulation, solar photovoltaics, and more efficient heating systems is another important strategy that can be taken at a local level and may actually generate a long-term savings to the firm or family that takes such actions in energy costs as well as reducing greenhouse gas emissions.

The up-front costs of such efforts are frequently daunting, even when the private investment will reduce private costs over the long run. By a public ballot approved by 81 % of the voters, Berkeley, California, has adopted a general policy to reduce emissions substantially over time. Berkeley FIRST (Financing Initiative for Renewable and Solar Technology) is designed to reduce the barrier of up-front costs. To participate in the program, a commercial or residential property owner asks a contractor for an estimate of the costs of new solar energy equipment and improvements to the energy efficiency of the building. The estimate is submitted to the city for review and to ensure that the owner has a clear title.

> After the municipality approves the application, the work is completed, a lien is placed on the property, and a check is issued to the property owner. A special tax is added to future property bills. If the property is sold before the end of the 20-year repayment period, the new owner pays the remaining special taxes as part of their property's annual tax bill. The interest component of the special tax payments will be tax deductible, similar to a home equity line or home mortgage (Pope et al. 2009: 25).

The demand for long-term and reasonable public loans has been high and Berkeley plans to increase the funds available to support this program over time.

Some local utilities in the United States are now also actively finding ways of reducing energy consumption by developing local monitoring systems that are then reported on the bills that customers receive. The Sacramento Municipal Utility District, for example, has tried various techniques including rebates for energy-saving appliances, but recently found a more effective technique.

> Last April (2008), it began sending out statements to 35,000 randomly selected customers, rating them on their energy use compared with that of neighbors in 100 homes of similar

size that used the same heating fuel. The customers were also compared with 20 neighbors who were especially efficient in saving energy.

Customers who score high earned two smiley faces on their statements. "Good" conservation got a single smiley face (Kaufman 2009).

The utility company conducted an initial assessment of this new strategy after using it for 6 months. The assessment found "that customers who received the personalized report reduced energy use by 2 % more than those who got standard statements" (Kaufman 2009). Using various forms of competition among households and groups, and feedback as to who is doing the best of reducing energy use, is a strategy for reducing emissions that is increasingly being adopted by college campuses, small cities, and utility firms around the country. University efforts to stimulate competition among campus dormitories to see who can reduce electricity consumption are proving to be effective (Peterson et al. 2007). Contemporary psychological studies have found that framing problems related to resource use in a social context do affect actions (Schultz et al. 2007; Mumford 2007).

Methods for developing reliable city-scale greenhouse gas inventories have been developed and tested (Ramaswami et al. 2008; Hillman and Ramaswami 1902). These are being used by many of the large number of cities across in multiple countries that have pledged to reduce GHG emissions consistent with the Kyoto Protocol. In the United States alone, the mayors of 1,026 cities have now joined the U.S. Conference of Mayors' Climate Protection Agreement to reduce GHG emissions of at least 5 % relative to 1990 levels (U.S. Mayors' Climate Protection Agreement 2010).

Multiple cities have started to initiate a variety of "green" initiatives that are prominently displayed on their home pages on the Web. The city of Toronto, for example, has established an "environmental portal" that announces more than a dozen current city policies, related publications, and meetings that are focused on climate change.[2] The city has supported a number of renewable energy projects including major investments averaging around $100,000 each for building rooftop gardens, solar photovoltaic panels on houses, and solar water-heating systems. The city also funds smaller projects to support neighborhood efforts to enhance the forested areas of local parks, local gardens, and for organizations at the local level that are working with communities to hold planning meetings to discuss better bicycle paths and other activities that can be undertaken at a small, neighborhood scale.

Large city mayors are also banding together to discuss actions to reduce carbon emissions that can be taken locally but if taken jointly, can have a much bigger effect. In October 2005, eighteen large cities sent representatives to London to examine actions that could be taken at a municipal level to reexamine various urban policies that could be revised including their own purchasing policies and ways of encouraging more investment in climate-friendly technologies in their cities. The C40 Large Cities Climate Summit occurred in May 2007 for the exchange of

[2]http://www.toronto.ca/environment/index.htm (accessed 9 February 2009).

information about many policies adopted to reduce emissions and the announcement of a $5 billion global Energy Efficiency Building Retrofit Program by the Clinton Climate Initiative.[3]

4.2 State-Level Projects in the United States

California is not only the twelfth largest emitter of greenhouse gases in the world—comparable to Australia's emissions—but it is now one of the leading governments to adopt policies related to climate change (Engel 2006). For example, in 2006, the California legislature passed legislation called the Global Warming Solutions Act, aimed at reducing greenhouse gas emissions by 25 % by 2020 by requiring drastic reductions from major industries including oil and gas refineries and utility plants.[4] The California Air Resources Board is charged with developing a market-based cap-and-trade program to implement the policy (Goulder 2007). This program is essentially a local version of the carbon market developed in the Kyoto Protocol. This is another example of how state-level policies can be designed to carry out policies originally formulated for a global level. The California policy reflects both its exposure to dramatic sea-level rises, if emission levels are not reduced, as well as a spur to the U.S. government to begin adopting policies at a national level.

The Colorado legislature passed State House Bill 08–1350, which was signed into law in 2008, to enable local governments to adopt policies similar to the Berkeley FIRST described above. The legislation allows municipalities in Colorado to finance approved building improvements and enables property owners to pay off capital investments made to decrease their use of fossil fuels for heating and electricity through a repayment over 20 years. In July of 2007, Governor Charlie Crist brought together government, business, and scientific leaders from across the state of Florida to discuss what actions could be taken by Florida to address climate change issues. At the conclusion of the meeting, several executive orders were signed to set out targets for reducing greenhouse gas emissions in Florida and to change the building code to require increased energy efficiency in new construction.[5]

4.3 Regional Efforts

Efforts are also being made among the states to develop joint policies. The Regional Greenhouse Gas Initiative (RGGI), joined by ten states located in the northeast and

[3] http://www.c40cities.org/ (accessed 1 February 2009).

[4] Global Warming Solutions Act of 2006, Calif. Assembly Bill 32.

[5] http://www.dep.state.fl.us/climatechange/ (accessed 27 June 2008).

mid-Atlantic regions of the United States, plans to cap CO_2 from the power sector by 10 % by 2018.[6] Further, RGGI is one of the first market-based efforts in the United States aimed at reducing greenhouse gas emissions by auctioning emission allowances and investing the proceeds in various forms of clean energy technologies and to green jobs in each of the states.

4.4 European Efforts

In Europe, various interventions tend to combine local, national, and European levels. The EU Emissions Trading Scheme (EU-ETS) was developed so as to reduce the economic costs of meeting its Kyoto target of 8 % CO_2 reduction by 2012. The EU-ETS is a major manifestation of the carbon market envisioned in the Kyoto Protocol. Around 10,000 large industrial plants in the power generation, iron and steel, glass, brick, and pottery industries in Europe are included, but not the transport sector. Operators of these facilities receive emission allowances that are good for a 1-year period. If they are not fully used by the assigned operator (after verification), the unused portion may be sold to other facilities that have not yet met their assigned target. The official data issued by the European Environmental Agency (EEA) in (2006) show that the EU members that had signed the Kyoto Agreement were able to achieve a 2 % cut in CO_2 emissions in 2005 compared to 1990 levels. CO_2 emissions are projected to decline further by 2010 compared to 2004 levels (EEA 2006: Sections 8 and 9). Thus, the decentralized impact of markets—resulting from the price of carbon that is itself now reflecting the externalities of climate change—helps to break up a global policy of the Kyoto treaty into individual actions by businesses and consumers.

5 Are Large-Scale Governments Usually Better Able to Cope with Collective Action?

While the presumption is made in many policy discussions that global solutions are necessary for coping with the problems of climate change because of the inadequacy of local and regional efforts, few of these analyses examine the problems that large-scale units themselves face in developing effective policies related to resources. Before making a commitment that the global level is the *only* scale in which to address climate change, one should at least reflect on past efforts to adopt uniform policies by very large entities intended to correct for problems of collective action.

[6] http://rggi.org/home/ (accessed 7 February 2009).

Contemporary assignments of regional, national, or international governments with the *exclusive* responsibility for providing local public goods and common-pool resources remove authority from local officials and citizens to solve local problems that differ from one location to the next. Doug Wilson, Research Director for the Institute for Fisheries Management and Coastal Community Development in Denmark, has recently reflected on the evolution of fisheries policies in the European Union.

> The Common Fisheries Policy (CFP) as it is called is an 'exclusive competence' of the European Union (EU) meaning that all decisions are taken at the level of the Union …
>
> The CFP is not only politically important within the overall effort to build a new kind of polity in Europe; it is also failing to do a very good job of maintaining sustainable fish stocks. Fisheries scientists tell us that, in 2003, 22 % of the fish caught from stocks managed by the CFP were taken from stocks that were smaller than they should have been for sustainable fishing. Neither scientists, fishers, government agencies, nor marine conservation groups are happy with the CFP, and there are myriad attempts to reform it. The reforms include better policy, better data gathering, a reduction in perverse subsidies to the fishing industry and, finally 30 years after most other fisheries management agencies had moved beyond top-down management, some serious attempts at stakeholder involvement (Wilson 2006: 7).

Other policies related to fisheries adopted by large-scale units have also exhibited major problems.[7] Exclusive Economic Zones (EEZs) were created in 1982 that extend 200 nautical miles along the borders between the ocean and coastal states and extended full sovereign powers to these states to manage these fisheries so that they are not overexploited (United Nations 1982). Instead of reducing overharvesting, however, many national governments subsidized expansions of fishing fleets that increased the demand on coastal fisheries and placed more in danger of overexploitation (Walters 1986). The models of fishery dynamics used by national governments tended to be relatively crude and led to inaccurate assessment of fishery stocks (Wilson 2002).[8]

Problems have also been noted regarding the way the Clean Development Mechanism (CDM) authorized by the Kyoto Protocol is being implemented in some settings. Several CDM processes are involved. One CDM process is supposed to substitute carbon-emitting energy-production processes with "green energy production." This process works approximately in this fashion: (1) a developing country decides to forego the construction of a power plant emitting substantial

[7]See Clark (2006) for a review of policies that have been adopted by national governments related to fisheries that initially led to perverse outcomes—some of which were eventually reversed.

[8]The Department of Fisheries and Oceans in Canada, for example, developed a model of stock regeneration for northern cod that scientists later found to be flawed. Local cod fishers in Newfoundland raised serious questions in the late 1980s and predicted a near-term collapse; the Canadian government refused to listen and assured doubters that their model was correct. In 1992, however, the cod stock collapsed and the Canadian government declared a moratorium on all fishing in Canadian waters, which has generated very substantial costs for local fishing villages dependent upon that stock that they had earlier managed relatively effectively (Finlayson 1994; Finlayson and McCay 1998).

greenhouse gases, (2) it plans to build a wind farm that is more "carbon friendly," and (3) the country applies for credit in the form of Certified Emissions Reductions (CERs) to sell to industrialized nations wishing to buy CERs as authorized by the Kyoto Protocol (Lohmann 2008). The income from selling the CERs can then, in principle, be allocated to the construction of the more expensive wind farm.

One problem with this highly complicated and flexible system is that it can be gamed (Sovacool and Brown 2009). Only 300 of the thousands of CDM projects that are underway have received accreditation by the UN. As it turns out, a large proportion of the CERs relate to triflouromethane, HFC-23, a greenhouse gas that is not associated with transportation or the production of power, but rather is used as a refrigerant—and a highly profitable greenhouse gas to claim to have "averted." As Sovacool and Brown (2009) conclude, the CDM has unfortunately made HFC-23 abatement too profitable.

> The sale of carbon credits generated from CERS for HFC-23 has become far more valuable than its production in the first place. Manufacturers of HFC-23, responding to market demand for CERs, started producing it just to offset it. Researchers at Stanford University have calculated that, at a result, payments to refrigerant manufacturers and carbon market investors to governments and compliance buyers for HFC-23 credits has exceeded €4.7 *billion* when the costs of merely abating HFC-23 would have been about €100 *million*—a major distortion of the market (Sovacool and Brown 2009: 14; citing Wara 2007 and Wara and Victor 2008).

Since the Bali round of negotiations held in December 2007, efforts to reduce emissions from deforestation and degradation (REDD) have been added to the portfolio of activities authorized under the Kyoto Protocol. Forest ecosystems do store an immense quantity of carbon, and the scientific foundation for adopting REDD is quite strong. Designing REDD projects so that new projects do not just lead to further leakage is a substantial problem. Ensuring that the rights of indigenous peoples are, at least, protected and ideally, enhanced as a result of support of their management of forest ecologies, is a goal that is widely shared by social activists at multiple scales. Accomplishing this goal while expanding the amount of forested land in developing counties would be economically efficient but a difficult challenge.[9] Currently there is considerable debate about this program and too few projects have been adopted to make a serious evaluation of the possibilities and threats (see Angelsen 2009; O'Sullivan 2008; Streck et al. 2008; Corbera and Brown 2008).

The discussion of problematic policies of large-scale governmental units related to climate change and other environmental policies is not meant to challenge the need for global policies related to climate change. The intent is to balance the major

[9]John Vidal (2008), in an article in *The Guardian* (17 October 2008), stressed that recognizing forest community rights would be a more cost-effective mechanism for reducing emissions than paying organizations to plant trees. "A study by Jeffrey Hatcher, an analyst with Rights and Resources in Washington, found that it costs about $3.50 (€2) per hectare to recognize forest people's land. The costs of protecting forests under REDD have been estimated at about €2000 per hectare.".

attention that has been given in the policy literature to the need for global solutions as the *only* strategy for coping with climate change. Extensive research on institutions related to environmental policies has repeatedly shown that creative, effective, and efficient policies, as well as disasters, have been implemented at *all* scales. Dealing with the complexity of environmental problems can lead to "negative learning" by scientists and policymakers at all scales (Oppenheimer et al. 2008). Reliance on a single "solution" may be more of a problem than a solution (Pritchett and Woolcock 2003).

It is important that we recognize that devising policies related to complex environmental processes is a grand challenge and reliance on one scale and one model alone to solve these problems is naïve. On the other hand, climate mitigation policies must eventually involve all of the countries of the world. Countries that are low emitters today, such as those in Africa and Latin America, are likely to increase their contributions significantly in the future. Further, as discussed below, those countries that are not included in agreements can undermine the efforts of those that are through "leakage" and behaving generally as free-riders. The efforts of many organizations at less-than-global scale can help reduce remissions to some extent, and they can also spur their own governments to take necessary national and international efforts.

6 Are There Too Many Actors Working on Climate Change?

One criticism leveled at current efforts to reduce greenhouse gas emissions is that the system is chaotic. Unquestionably, many problems characterize the current efforts. Many of these do relate to the lack of effective policies at an international level. Further, some of the projects that are overtly aimed at reducing greenhouse gas emissions may well be ineffective, too costly, and rewarding actors who are not genuinely interested in reducing the threat of climate change, but are rather looking for opportunities to gain funds and search for minimal ways of meeting project announcements.

Thus, it is important that we examine some of the key problems that have been identified as plaguing efforts to control greenhouse gas emissions. Recognition of problems is essential to start serious efforts to find methods to reduce them. The problems raised most frequently relate to leakage, inconsistent policies, free-riding, and inadequate certification.

Leakage is one of the problems frequently identified with subnational projects aimed at reducing carbon emissions (Burniaux and Martins 2010). Two types of leakage can occur from policies adopted at less-than-global scale: location and market leakage (Ebeling 2008: 49–51). Leakage between locations occurs when an activity that would have occurred in X location is shifted to Y location because of a climate change project that occurs in X location (Sovacool and Brown 2009). The EU's efforts to reduce emissions from industrial producers may, in some cases, simply shift the emissions that would have been produced by a European chemical

firm to another location in a developing country where the costs of production may be lower. Carbon is still emitted, however, in the production of chemicals plus the carbon emitted in transportation of the chemicals to European locations (Chomitz 2002). Market leakage refers to the changes in the price structure that may occur by restrictions placed on harvesting from forests. Such restrictions reduce the volume of timber and other forest products generated in one area. This stimulates an increase in the prices of these products. If everything goes well, higher prices encourage the intensification of agricultural and forest production in other areas and it does not stimulate more deforestation. "In a less favorable scenario, particularly when land-use regulations are poorly enforced, higher prices provide an additional incentive to clear forests for timber or agriculture elsewhere, thereby reducing the net benefits of the climate mitigation project" (Ebeling 2008: 50).

Whenever actions taken by some individuals or organizations benefit a larger group, a risk exists that some participants will free-ride on the efforts of others and not contribute at all or not contribute an appropriate share. At the current time, there are many governmental and private entities at multiple scales that are increasing their greenhouse gas emissions substantially—especially in the developing world—without adopting any policies to reduce emissions. This is a major problem. Current debates over who caused the human threat and thus who should pay the most in the future are legitimate debates. At the same time, they may also cover a free-riding strategy by at least some of those involved.

For policies adopted at any scale that provide diverse rewards for projects that reduce greenhouse gas emissions, a need exists for skilled personnel to certify that the project does indeed reduce ambient CO_2 by some specified amount over a defined time period. A very active new industry of "global consultants" has emerged. While many consultants do have good scientific training, the greatly increased need for certification has generated opportunities for at least some contractors who lack appropriate skills to earn money in the new "certification game." Sovacool and Brown (2009: 14) report on one study that evaluated 93 randomly chosen CDM projects and "found that in a majority of cases the consultants hired to validate CERs did not possess the requisite knowledge needed to approve projects, were overworked, did not follow instructions, and spent only a few hours evaluating each case."

Problems do exist in the design and administration of projects at multiple scales trying to deal with climate change. There is a lot to learn, however, from these efforts. It is essential that we recognize: (1) the complexity of causes of climate change; (2) the challenge of acquiring knowledge about causes and effects in a world that is changing rapidly; (3) the wide diversity of policies that can lead to reduced emissions but might also enable opportunistic efforts to obtain a flow of funds by appearing to reduce emissions while not having a real impact, or worse, effectively increasing rather than decreasing emissions; (4) the opportunities that major sources of funding open up for policy experiments if funds are also allocated to monitoring and evaluation of the benefits and costs of the experiment; and (5) that all policies adopted at any scale can generate errors, but without trial and error, learning cannot occur.

Acknowledging the complexity of the problem, as well as the relatively recent agreement among scientists about the human causes of climate change, leads to

recognition that just waiting for effective policies to be established at the global level is unreasonable. Rather than only a global effort, it would be better to self-consciously adopt a polycentric approach to the problem of climate change in order to gain the benefits at multiple scales as well as to encourage experimentation and learning from diverse policies adopted by multiple scales. Less-than-global efforts may also spur essential efforts at a global level.

Further, the extensive empirical research on collective action discussed above has repeatedly identified a necessary central core of trust and reciprocity among those involved to be associated with successful levels of collective action. If the *only* policy adopted related to climate change was at the global scale, it is particularly difficult to increase the trust that citizens and firms need to have that other citizens and firms located halfway around the globe as well as nearby are taking similar actions. Effective monitoring is needed both to catch offenders as well as assuring those who cooperate with costly policies that they are not suckers. One of the core findings from recent research on the sustainability of forests in a dozen countries around the world is the importance of users having a strong commitment to collective action to protect their forests. As a result, in the forests where users themselves contribute to monitoring efforts, their forests are in better condition (Gibson et al. 2005; Hayes and Ostrom 2005; Ostrom and Nagendra 2006; Coleman 2009; Chhatre and Agrawal 2008). In these settings, users are able to engage in sustainable exploitation of natural resources (Figuières 2010 and Tidball 2010). Citizens living in a community that has adopted policies to restrain the emissions of greenhouse gases interact in a variety of local settings where they can directly question each other if inconsistent behavior is observed. When most of their friends, neighbors, and coworkers appear to be following rules to reduce their carbon emissions, each citizen gains trust that they are not foolish for complying themselves. This is another complementary aspect of adopting policies at local levels that are consistent with the goals of policies at regional, national, and global levels.

7 Conclusion

Given that the recognition of the danger of climate change among citizens and public officials is still relatively recent, and that major debates about potential solutions are continuing, one cannot expect a global solution to be constructed in the near future. Building a global regime is a necessity (Barrett 2007), but building a polycentric system starts the process of reducing greenhouses gas emissions and acts as a spur to national and international regimes to get their act together!

Recognizing the potential of building more effective ways of reducing energy use at multiple scales is thus an important step forward. Further, an important strategy for reducing CO_2 in the atmosphere is developing more effective policies for protecting ecosystem services—particularly those related to carbon sequestration. Developing effective and adaptive programs, however, requires selecting appropriate areas, developing plans for leaving some areas untouched, and for making major

investments in the flora and fauna as well as the technological infrastructure of other areas (Michel 2009). This requires substantial investment in scientific modeling (Nelson et al. 2009) and use of geographic information systems combined with in-depth knowledge of the biophysical settings to map ecological systems over time (Daily et al. 2009). The models, however, need to be developed at multiple scales so that relevant decision-making units can address what policies can be adopted to improve carbon sequestration that fits the ecology at that particular scale.

Building a strong commitment to finding ways of reducing individual emissions is an important element for coping with climate change. Building such a commitment can be more effectively undertaken in small- to medium-scale governance units that are linked together through information networks and monitoring at all levels. Global policies are indeed necessary but they are not sufficient.

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