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Taking Climate Change by Storm: Theorizing Global and Local Policy-Making in Response to Extreme Weather Events

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INTRODUCTION

Mounting evidence suggests that anthropogenic climate change leads to significant increases in the frequency, duration, spatial extent, severity, and timing of extreme weather and climate events.[1] With varying degrees of confidence, current scientific models project a substantial warming in temperature extremes, an increase in the frequency of heavy precipitation, an increase in the average tropical cyclone wind speed, an intensification of droughts, and a rise in sea levels by the end of the 21st century.[2] Floods, droughts, and hurricanes, while more uncertain in terms of their links to climate change, may increase risk and cause more damage to the growing population and infrastructures

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1. MANAGING THE RISKS OF EXTREME EVENTS AND DISASTERS TO ADVANCE CLIMATE CHANGE ADAPTATION 4, 7 (Christopher B. Field et al. eds., Cambridge Univ. Press 2012) [hereinafter SREX Report], *available at* http://ipcc-wg2.gov/SREX. For a discussion of the trends in the United States, see *Climate Change Impacts in the United States: The Third National Climate Assessment,* J.M. Melillo, Terese (T.C.) Richmond, & G.W. Yohe, eds., U.S. Global Change Research Program 35-43 (2014) [hereinafter *U.S. Third National Climate Assessment*].

2. SREX Report, *supra* note 1, at 13-15.

in vulnerable regions.[3]

"Disasters are often thought of as events occurring at a specific location whereas climate change is thought of as a global or regional phenomenon."[4] This view is now evolving as local disasters are recognized as having a relationship with broader climate change dynamics.[5] However, "climate change projections do not provide precise information at a local scale."[6] In other words, while scientific knowledge on the likely occurrence and severity of extreme weather events is improving at the global scale, that knowledge does not translate well into local predictions.[7] There are some prospects for reducing this disconnect in the future, but the recent Intergovernmental Panel on Climate Change's 2012 SREX Report recognizes that they have not yet materialized.[8]

By contrast, policy interventions to adapt to, or mitigate, the impact of extreme weather events tends to be easier to craft at the local scale, with fewer actors involved and more pressing concerns for effectiveness, than at the continental or global scale, where actors have too many incentives to defect from a common undertaking: a classic collective action problem.[9]

Scientific uncertainty and policy effectiveness regarding climate change, then, appear to operate inversely. At the global level where the scientific consensus on climate change is the strongest, policy-makers have been the least successful at undertaking effective action.[10] At the local level, where policy-makers are typically more able to overcome

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3. *See, e.g.*, *id.* at 18-19.

4. *Id.* at 427.

5. *Id.*

6. *Id.*

7. *See id.*

8. *See id.* at 17.

9. *See* Lisa Schenck, *Climate Change "Crisis" – Struggling for Worldwide Collective Action*, 19 COLO. J. INT'L ENVTL. L. & POL'Y 319, 334 (2008) and accompanying footnotes.

10. *See generally* Elke Schüssler, Charles-Clemens Rüling, & Bettina B.F. Wittneben, *On Melting Summits: The Limitations of Field-Configuring Events as Catalysts of Change in Transnational Climate Policy*, 57 ACAD. OF MGMT. J. 140 (2014).

coordination problems, the science of climate change has a much higher degree of uncertainty. These trends are even more accentuated with respect to the scientific understanding of extreme climate events and the likelihood of political coordination at various scales.

The main contribution of this Article is to theorize and illustrate how the elements of scale, scientific uncertainty, and collective action contribute to the success or failure of particular types of policy. Borrowing from economics literature, we characterize this trilateral relationship as a "triangle of impossibilities." This Article hypothesizes that collective action problems account in part for the paradox that policy-makers are least able to effectively respond to the challenge of extreme weather events at the scale where scientific knowledge is the most accurate. A successful policy, therefore, is one that considers and overcomes the conundrum that the triangle of impossibilities presents. This Article aims to help direct the scientific community towards the types of research efforts that will positively impact the policy sphere. For lawyers and policy-makers, this Article will provide a guide of "best practices" that aim to overcome the triangle of impossibilities, taking into account the lessons learned from previously successful and unsuccessful policies.

This Article surveys literature from the sciences, law, and policy to show that as scientific uncertainty regarding extreme weather events decreases when we move from the local scale to the global scale, the ability of policy-makers to respond correspondingly decreases. In other words, while there is fairly reliable modeling of future extreme weather event patterns at the global scale, policy-makers have proven, with the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC), that they are unable to agree on a world-wide basis about how to manage climate change. By contrast, policy-makers would be more able and willing to implement local remediation and mitigation plans, but the scientific prediction of extreme weather patterns at the local level is much more uncertain. This research approach of comparing extreme weather policy across spatial scales enables us to suggest certain policy designs, which are based on the recent developments of scientific modeling and the correlation between scientific uncertainty, spatial scale, and well-established political theory on collective action.

While keeping in mind that this Article focuses on multi-scale solutions to the difficulties of extreme weather policy-making, helpful notes can be drawn from the literature on domestic regulation and, in particular, from the field of ecosystem management.[11] This area has long perceived obstacles to finding a workable and ecologically wise governance mechanism to advance regulatory proposals.[12] Studies of community-based resource management regimes have suggested that relevant institutional innovations may in fact occur at multiple semi-autonomous scales, allowing organizations of all levels to perceive, respond, and adapt to ecological information.[13] This "collaborative ecosystem governance" model would explicitly recognize the need for integrated and holistic management, and would "grapple[] with questions of scale and complexity in ecosystem management, emphasizing locally or regionally tailored solutions within broader structures of coordination and public accountability."[14] Ecosystem governance theory recognizes the temptation and fallacy of waiting for better information before undertaking action and seeks to transcend the issue by developing institutions that are open and adaptive to new knowledge. As Karkkainen puts it, "although we can never know enough at any given moment to decide what is right or best, we also cannot afford to defer decision-making until 'all the information is in' for the simple

11. *See generally* Lee P. Breckenridge, *Special Challenges of Transboundary Coordination in Restoring Freshwater Ecosystems*, 19 PAC. MCGEORGE GLOBAL BUS. & DEV. L.J. 13 (2006).

12. *Id.* at 13-14.

13. *See* Robert W. Adler, *Addressing Barriers to Watershed Protection*, 25 ENVTL. L. 973, 1088-92 (1995) (recommending multiple scales of organization and both regional and local initiative); *see also* Bradley C. Karkkainen, *Collaborative Ecosystem Governance: Scale, Complexity, and Dynamism,* 21 VA. ENVTL. L.J. 189, 226-33 (emphasizing the importance of collaboration and cooperative solutions across multiple scales).

14. Karkkainen, *supra* note 13, at 193.

and inescapable reason that all the information will never be in."[15]

A NOTE ON COLLECTIVE ACTION THEORY

Collective action theory is most famously developed in Mancur Olson's influential work, *The Logic of Collective Action*.[16] It predicts that when a common good is involved, members of the group benefitting from the good have an incentive to free ride in the hope of benefitting from the good without bearing the costs. When taken in the aggregate these individual behaviors mean that it is unlikely that the group will organize itself to share the cost of the good. The good will therefore not be provided unless one member is willing to provide the good to the others. "Common" or "collective" goods are available to every individual jointly, such that the consumption by one individual does not decrease others' ability to consume it, and no individual can be excluded from consumption.[17] Global climate security is an archetypical common good, and commentators have applied collective action theory to climate change.[18] For purposes of the narrower topic of this Article a critical objective is to explain why the collective action problem can be expected to be even harder to overcome with respect to extreme climate events management. Here the more limited literature on the conditions that might allow regulatory success in the face of

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15. *Id.* at 203; *see also* George Frampton, *Ecosystem Management in the Clinton Administration,* 7 DUKE ENVTL. L. & POL'Y F. 39, 44 (1996) ("[T]here is never enough information to feel confident about a particular decision. No key ecosystem management decision ever gets made in a setting of adequate information.").

16. *See generally* MANCUR OLSON, THE LOGIC OF COLLECTIVE ACTION: PUBLIC GOODS AND THE THEORY OF GROUPS (Harvard Univ. Press rev. ed. 1971); *see also* Richard E. Levy, *The Tie That Binds: Some Thoughts About the Rule of Law, Law and Economics, Collective Action Theory, Reciprocity, and Heisenberg's Uncertainty Principle*, 56 U. KAN. L. REV. 901, 906 (2008).

17. *See generally* OLSON, *supra* note 16.

18. *See* Paul G. Harris, *Collective Action on Climate Change: The Logic of Regime Failure*, 47 NAT. RESOURCES J., 195, 195 (2007); *see also* Simon Caney, *Cosmopolitan Justice, Responsibility, and Global Climate Change*, 18 LEIDEN J. OF INT'L. L. 747, 747-48, 758 (2005).

a potential collective action problem will provide a useful starting point.[19]

Part I presents the difficult dialectic between uncertainty in climate change science and the ability of policy-makers to coordinate on a global scale. For this, we identify a series of scientific "moments" that lead to different approaches in climate change policy-making. This is relevant when responding to extreme weather events because the dynamic between scientific uncertainty at various scales and policy-making is even more exacerbated in that field than it is with respect to climate change generally. Part II attempts to theorize how policy-makers can transcend the collective action dilemma to respond more effectively to the challenges of extreme weather events. It proposes concrete regulatory and policy instruments that could overcome collective action roadblocks and present a matrix, which illustrates the lessons learned in past policy to better predict the success of future policies.

I. Scientific Uncertainty, Collective Action, and Policy-making in Response to Extreme Weather Events: A Difficult Dialectic

Historically, we can identify three moments in the relationship between science, uncertainty, and regulation in the climate change field. Each encapsulates a different model for addressing regulation in the face of uncertainty and each therefore holds different lessons for the issue of managing extreme weather events. This Part analyzes each of those moments and examines what they might imply for policy-makers' ability to tackle the challenges of extreme weather events in the face of scientific uncertainty.

A. *First Moment: No Harm, No Regulation*

The Swedish scientist Svante Arrhenius was the first to suggest in 1896 that fossil fuel combustion could lead to global warming, and proposed a link between atmospheric

19. Harris, *supra* note 18, at 196-98.

carbon dioxide and temperature.[20] Climate science in the late 19th and early 20th centuries suffered from lack of adequate observations and insufficient physical understanding.[21] The development of the first climate model by Manabe and Wetherald in 1967[22] ushered in a new era. However, the implications of chaos theory, through pioneering work by Ed Lorenz in the 1970s,[23] made scientists wonder about the intrinsic predictability of weather and climate systems. Nonetheless, despite large uncertainties and notable disagreements, the scientific community was beginning to seriously consider and debate the possibility of human-induced warming.[24]

These limitations of the scientific understanding shaped the regulatory response. Traditionally, international law has held that states are free to pursue activities that are not prohibited and that do not infringe upon other states' sovereignty.[25] Transboundary harm therefore had to be demonstrated before states would consider regulating or banning it, or perhaps even holding other states accountable for the damage.[26] As more scientific certainty emerged

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20. *See generally* Svante Arrhenius, *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground*, 41 PHIL. MAG. & J. SCI. 237 (1896), *available at* http://www.globalwarmingart.com/images/1/18/Arrhenius.pdf.

21. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *Summary for Policymakers*, *in* CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS 4 (Thomas F. Stocker et al., eds., Cambridge Univ. Press 2013) [hereinafter IPCC, *Summary for Policymakers*], *available at* http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf.

22. *See generally* Syukuro Manabe & Richard T. Wetherald, *Thermal Equilibrium of the Atmosphere with a Given Distribution of Relative Humidity*, 24 J. ATMOSPHERIC SCI. 241 (1967).

23. *See generally* Edward N. Lorenz, *Deterministic Nonperiodic Flow*, 20 J. ATMOSPHERIC SCI. 130 (1963).

24. SPENCER WEART, *General Circulation Models of Climate, in* THE DISCOVERY OF GLOBAL WARMING (2014), http://aip.org/history/climate/GCM.htm (supplementing Weart's book of the same title).

25. *See* S.S. "Lotus" (Fr. v. Turk.), Judgment, 1927 P.C.I.J. (ser. A) No. 10 at 18-19 (Sept. 7); Trail Smelter Case (U.S. v. Can.), 3 R.I.A.A. 1905, 1963 (Mar. 11, 1941).

26. *See* "Lotus," 1927 P.C.I.J. (ser. A) No. 10; Trail Smelter Case, 3 R.I.A.A. 1905.

regarding the harmful effect of human activities on global commons such as the environment, the high seas, and the atmosphere, states undertook to regulate those products or activities. For example, after chlorofluorocarbons (CFCs) were identified as a major cause of ozone depletion, the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol instituted a phase-out, eventually leading to the ban on production of the product and the partial recovery of the ozone layer.[27] The predominant regulation was reactionary rather than precautionary. As such, the uncertainties in the scientific understanding of climate change would have undermined regulatory responses to climate change.

The lessons for extreme weather event policy of this type of relationship between regulation and scientific uncertainty are limited. Since extreme weather events are not caused by any singly identifiable activity,[28] they are unlikely to be regulated by this regulatory approach of ex-post harm reduction. Attempts at regulating a downstream transboundary harm without being able to reach its cause have had limited success. The Convention to Combat Desertification (UNCCD), for instance, acknowledges the need to address increasing desertification in Sub-Saharan Africa, and despite most countries of the region being parties to the convention, its effect has been limited at best.[29] A more positive attempt to regulate a harm with complex and diffuse causes may be found in the Med Plan.[30] The Med Plan brought together littoral states and the European

27. *See* Montreal Protocol on Substances That Deplete the Ozone Layer, art. 2, *opened for signature*, Sept. 16, 1987, 1522 U.N.T.S. 29; Convention for the Protection of the Ozone Layer, art. 2, o*pened for signature* Mar. 22, 1985, T.I.A.S. No. 11,097, 1513 U.N.T.S. 293.

28. IPCC, *Summary for Policymakers*, *supra* note 21, at 18, 20, 23.

29. Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa 108-09, *opened for signature* Oct. 14, 1994, 1954 U.N.T.S. 3 [hereinafter Convention to Combat Desertification]; *see also* Christoph Kohlmeyer & Ralf Wyrwinski, *The Convention to Combat Desertification: Relevant or a Relict?*, 14 RURAL 21, no. 1, 2007, at 26 (Jan. 2007), *available at* http://www.rural21.com/uploads/media/ELR_The_outlook_for_the_UNCCD_0107.pdf.

30. Harris, *supra* note 18, at 205.

Community to protect the Mediterranean Sea's environment from pollutants that were contaminating the water and surrounding state shores.[31] The moderate success of this plan is thought to be attributed to an increase of "'governmental learning,' a process whereby scientists and ecologists informed domestic and foreign policy-makers about the extent of the problem so as to elicit their interest in protecting the Mediterranean."[32] Following such involvement, governments were able to overcome the domination of stronger states and recalculate their interests in light of the "professional campaign [led by ecologists and marine scientists] to spread information."[33]

B. *Second Moment: "If You Break It, You Buy It"*

As technology advanced, so did our understanding of the climate system and the capabilities of scientific models of climate. From the late 1970s through the 1990s, two major developments transformed the field. First, the use of remote sensors, such as radar and satellite measurements, morphed climate and earth sciences from data poor to data rich disciplines. Second, with improved physical understanding and rapid advances in computing power, scientists were able to develop large-scale global models that improved projections on climate change. Consensus in the scientific community started to form about anthropogenic warming by the late 1980s, and the Intergovernmental Panel on Climate Change (IPCC) was established in 1988.[34] Although the understanding of atmospheric physics and chemistry improved greatly during this time, deep uncertainties continued to remain. In particular, debates remained about the nature and cause of warming temperatures around the world, with larger uncertainties in the characterization and attribution of extreme weather or hydrological events. The first, second, and third assessment reports of the IPCC were

31. *Id.*

32. *Id.* at 206.

33. *Id.*

34. *History*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, http://www.ipcc.ch/organization/organization_history.shtml (last visited May 19, 2014).

published in 1990, 1995, and 2001, respectively, and gradually provided more credence to the possibility of anthropogenic warming.[35] While the human activity contribution to climate change is now well established, the statements continued to be caveated with various measures of uncertainties.[36]

This decrease in uncertainty in our understanding of atmospheric physics and chemistry opened up the possibility of global treaties. As the success of the Montreal Protocol demonstrates, the ability of atmospheric scientists to firmly establish the scientific validity of their claims and influence policy was becoming clear.[37] As Harris notes, "[a]ccording to Benedick's account, 'Close collaboration between scientists and key government officials who became convinced of the long-term dangers ultimately prevailed over more parochial and short-run interests of national politicians.'"[38] Discussing the success of the Montreal Protocol, Harris wrote that "[i]t was partly due to the influence of scientists that political leaders took action on ozone despite there still being considerable uncertainty about the full nature of the problem."[39] The atmospheric scientists were eventually awarded the Nobel Prize in Chemistry for their contributions.[40] However, despite this progress in atmospheric chemistry and their impacts on global treaties of immense societal importance, debates continued to linger in areas such as climate science.

The policy response in the 1970s and 1980s reflected the rather gradual shift from the debate on whether climate change was happening to how it was unfolding. The fourth

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35. For an electronic version of the IPCC Assessment Reports, see *Reports*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1.

36. *See generally* IPCC, *Summary for Policymakers*, *supra* note 21.

37. Harris, *supra* note 18, at 208.

38. *Id.*

39. *Id.*

40. Press Release, The Royal Swedish Academy of Sciences (Oct. 11, 1995), *available at* http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1995/press.html.

assessment report (AR4) of the IPCC in 2007 was the first to conclude, based on the available scientific literature, that (a) global warming was indeed happening, and (b) anthropogenic emissions were the most likely cause.[41] The anticipated impact of such a major declaration was expected to be large, not just on climate science, but also on international treaties and national policy. The IPCC was awarded the Nobel Peace Prize for this effort.[42] However, the impact in practice has fallen short.

With human contributions identified as a cause, the regulatory response was to allocate responsibility based on what each state had historically contributed to emissions and other climate-changing activities. This focus on past contributions led to the development of principles such as "polluter-pays" and "common but differentiated responsibilit[ies]."[43] Further scientific advancements on the understanding of greenhouse gas (GHG) emissions' contribution to climate change allowed policy-makers to use not only current emissions, but also predictions of future emissions to apportion the burden among the states. Policies of the 1990s and early 2000s reflected these advancements by introducing carbon-trading ideas.[44] In this regulatory

41. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT 30, 37 (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

42. Press Release, The Norwegian Nobel Committee (Oct. 27, 2007), *available at* http://www.nobelprize.org/nobel_prizes/peace/laureates/2007/press.html.

43. Rio Declaration on Environment and Development, Principles 7, 15, *adopted* June 13, 1992, 31 I.L.M. 874, 877, 879.

44. Aside from the Kyoto Protocol carbon trading scheme, a number of entities have developed carbon trading schemes, including Australia, New Zealand, the EU, Tokyo, and several U.S. states (including the New York state Regional Greenhouse Gas Initiative, the Chicago Climate Exchange, and five U.S. states in conjunction with four Canadian provinces through the Western Climate Initiative). *See* Climate Change Response (Emissions Trading) Amendment Act 2008 (N.Z.); *About the WCI*, WESTERN CLIMATE INITIATIVE, http://www.westernclimateinitiative.org/organization (last visited May 19, 2014); *Chicago Climate Exchange*, INTERCONTINENTAL EXCHANGE, https://www.theice.com/ccx.jhtml (last visited May 19, 2014); *Emissions Trading System*, EUROPEAN COMMISSION, http://ec.europa.eu/clima/policies/ets/index_en.htm (last updated May 14, 2014); *Greenhouse Gas Reduction Scheme*, INDEPENDENT PRICING AND REGULATORY TRIBUNAL, http://www.ipart.nsw.gov.au/Home/Industries/Electricity/Greenhouse_Gas_Reduction_Scheme (last visited May 19, 2014); *The*

model, the difficulty is to allocate shares and to enforce the commitments framework on reluctant actors who have already enjoyed the benefit of their contribution to the common harm and are less eager to bear the cost. The incentive to free-ride is extremely high, both for historic contributors and for prospective contributors. As has been amply demonstrated by the experience of the Kyoto Protocol,[45] the collective action problem is acute. Preliminary reports about the upcoming report from the UN Panel on Climate Change (i.e., the Fifth Assessment Report or AR5) and the recent literature suggest that only limited improvements can be expected from the current generation of models, such that the scientific uncertainty regarding global climate modeling is unlikely to dramatically decrease in the near future.[46]

The benefit of this model is that scientific uncertainty regarding the location of the harm is irrelevant to legal commitments. The regulatory framework is solely concerned with who is responsible for past harm, who is a current contributor, and who will be a future contributor. The UNFCCC reflects this approach to some extent. It recognizes that states have contributed diversely to the harm and calls

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Regional Greenhouse Gas Initiative, N.Y. DEP'T OF ENVTL. CONSERVATION, http://www.dec.ny.gov/energy/rggi.html (last visited May 19, 2014); *Tokyo Kicks Off Carbon Trading Scheme*, THE GUARDIAN (Apr. 8, 2010), http://www.theguardian.com/environment/2010/apr/08/tokyo-carbon-trading-scheme.

45. The status of ratifications shows that some emissions contributors listed in Annex I of the UNFCCC are not are not parties to the Protocol, which would have resulted in binding emission targets for these countries. Kyoto Protocol to the United Nations Framework Convention on Climate Change, art. 2, Dec. 10, 1997, U.N. Doc FCCC/CP/1997/7/Add.1, 37 I.L.M. 22 (1998) [hereinafter Kyoto Protocol]. For a list of Annex I countries, *see* United Nations Framework Convention on Climate Change, Annex I, May 9, 1992, S. Treaty Doc No. 102-38, 1771 U.N.T.S. 107 [hereinafter UNFCCC].

46. *See generally* Reto Knutti & Jan Sedlácek, *Robustness and Uncertainties in the New CMIP5 Climate Model Projections*, NATURE CLIMATE CHANGE, 1 (2012), *available at* http://www.iac.ethz.ch/people/knuttir/papers/knutti12natcc.pdf; Mark Maslin & Patrick Austin, *Uncertainty: Climate Models At Their Limit?*, 486 NATURE 183 (2012), *available at* http://www.nature.com/nature/journal/v486/n7402/full/486183a.html; *see also* IPCC, *Summary for Policymakers*, *supra* note 21, at 15.

for commitments on that basis.[47] The Kyoto Protocol's 1990 baselines and its tiered commitment system is further embodiment of this model. Historic contributors to GHG emissions have binding reduction targets (the Annex I countries) and the debate raged over whether China, a fast growing but recent contributor, should also have been included in that group.[48]

This regulatory model holds valuable lessons in the extreme weather event context. Since it is concerned with apportioning obligations in relation to the contribution to the root cause of the harm, scientific uncertainty regarding where extreme weather might occur is largely irrelevant to policy-making. The only pertinent issue is whether GHG emissions are the cause of increased extreme weather events: if science can give a reasonable level of certainty that the causal relationship exists, then apportioning principles could form the basis for regulation.

The SREX Report provides a bifurcated answer to this question. On one hand, it establishes with a fairly high degree of certainty a causal relationship between anthropogenic climate change and an increase in the frequency, duration, and severity of heat waves and precipitations.[49] On the other hand, it provides less clarity with respect to a possible link between increased floods, hurricanes, and droughts, and anthropogenic climate change.[50] Uncertainty is likely to reduce with respect to

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47. UNFCCC, *supra* note 45, art. 3(1) ("The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof."); *id.* art. (4)(2)(a) (". . . and taking into account the differences in these Parties' starting points and approaches, economic structures and resource bases, the need to maintain strong and sustainable economic growth, available technologies and other individual circumstances, as well as the need for equitable and appropriate contributions by each of these Parties to the global effort regarding that objective.").

48. Kyoto Protocol, *supra* note 45. For a list of Annex I countries, see UNFCCC, *supra* note 45.

49. SREX Report, *supra* note 1, at 119.

50. *Id.*

causation dynamics for precipitation extremes, but less progress is expected in the understanding of the relationship between climate change and increased hurricanes and floods.[51]

Establishing the link between anthropogenic climate change and extreme weather events is an issue of attribution. As climate change is by nature a statistical phenomenon, scientists cannot assert that any particular event is directly attributable to global warming, but scientists have proven that climate change has had a significant impact on extreme weather events.[52] Jerry Meehl of the National Center for Atmospheric Research (NCAR) analogizes the use of steroids in baseball[53]: a baseball player has a certain average level of home run production in his baseball career before he allegedly starts taking steroids. After that, his home run production increases, and he sets the single season record for home runs. While we cannot say that any particular home run was enabled by the use of performance enhancers, we know that the odds of hitting a home run have increased.[54]

Climate change has caused a similar shift in relation to the occurrence of extreme weather events. "A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of weather and climate extremes, and can result in unprecedented extremes."[55] Because the probability of changes in climate extremes has generally increased due to climate change, it may be possible to attribute the occurrence of a specific extreme weather

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51. Usually, this is a combination of the unknowns in physics, inability of models to capture even that physics that is known, and intrinsic system uncertainties. Some of these issues are caused by long-standing gaps in the science and models. Predictability (i.e., intrinsic variability issues) is more of an issue for hurricanes and tornadoes and less for temperature extremes, with heavy rain somewhere in between.

52. SREX Report, *supra* note 1, at 8-9, 127.

53. AtmosNews, *Steroids, Baseball, and Climate Change*, UNIV. CORP. FOR ATMOSPHERIC RESEARCH (Feb. 2012), https://www2.ucar.edu/atmosnews/attribution/steroids-baseball-climate-change.

54. *Id.*

55. SREX Report, *supra* note 1, at 115.

event to the changed probability of its occurrence.[56] The SREX Report notes that "climate models can sometimes be used to identify if specific factors are changing the likelihood of the occurrence of extreme events" as was the case for the European heat wave in 2003.[57] The SREX Report recalls that "a model experiment indicated that human influences more than doubled the likelihood of having a summer in Europe as hot as that of 2003."[58]

This scientific uncertainty regarding contribution to climate change and extreme weather events may undermine a regulatory policy model where obligations are apportioned to causation. The implications are far-reaching. While causation and apportioning between levels of emissions and increased extreme weather events is fairly well established, a breakdown by classes of weather events would be more difficult to define. Mitigation and remediation policies, if passed on an apportioning model between responsibility for climate change emissions and resulting damages, would have to be devised on an aggregate basis, lumping together all damages from extreme weather events. However, the vulnerability to extreme events varies by communities. Even if it is established that the emitters bear a responsibility to prevent, mitigate, and alleviate, what responsibility befalls on the local community to also reduce its vulnerability? For instance, an alluvial plain community that is more vulnerable to floods due to climate change should receive, under an apportionment model, some compensation for the damages incurred, but does it also mean that such a community should limit its exposure by not further developing in that area?

This "moment" in regulatory history also saw a shift from strictly reactionary policy-making to some level of precautionary regulation.[59] The argument is that the precautionary principle justifies regulation in the absence of

56. *Id.* at 127.

57. *Id.*

58. *Id.*

59. Sonia Boutillon, Student Note, *The Precautionary Principle: Development of an International Standard*, 23 MICH. J. INT'L L. 429, 430-31 (2002).

scientific certainty if there is a substantial risk of irreversible harm.[60] The main drawback for this regulatory model is that it would only be effective at managing extreme weather events at the global scale by eliminating their general cause: climate change. In other words, assuming that climate change is the main cause of increased extreme weather events, this model will only work if it successfully prevents or reverses climate change. There are increasing indications, however, that prevention of climate change has failed and that reversal is unlikely in the short to medium term.[61]

C. *Third Moment: Think Global, Act Local?*

Progress on the scientific understanding of climate change was significant for a number of years and several hypotheses about global warming, anthropogenic causes, extreme weather events, and their impacts on natural hazards and disasters, were examined and accepted with various margins of uncertainty.[62] However, towards the latter part of the 1990s and into the new millennium, questions arose regarding the gains achieved from successive generation global climate models and the uncertainties these gains yielded. Scientists know much more about climate change, with a greater degree of certainty in some cases, but also recognize that in many important situations, scientific understanding is still limited and improvements on current models are few and far between.[63]

With both the science and the policy-making at a standstill at the global scale, the action has moved to the regional and local scales. Climate change modeling now aims to improve the resolution of global scale models, as well as regional models and statistical methods, and address discrepancies between global, regional, and local predictions. In particular, scientists aimed to downscale the results at the local level by using regional climate models and/or statistical

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60. *Id.*

61. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 1995, at 28 (1995), *available at* http://www.ipcc.ch/pdf/climate-changes-1995/ipcc-2nd-assessment/2nd-assessment-en.pdf.

62. SREX Report, *supra* note 1, at 6.

63. IPCC, *Summary for Policymakers*, *supra* note 21, at 15-16.

procedures. In pursuance of that goal, scientists have established systematic procedures to further develop and manage simulations from global and regional climate models. Scientists are now observing and modeling a wider range of earth system components and processes, such as land and vegetation models, ocean models, and sea ice models, in an effort to understand the contributions of these processes and improve overall projections.[64]

International policy from the late 2000s to date has mirrored this refocus. In fact, the recently released Fifth Assessment Report from the IPCC calls for immediate action to head off the worst of the damage impacts of climate change, noting that "adaptation and mitigation choices in the near-term will affect the risks of climate change throughout the 21st century."[65] Regional organizations, such as APEC[66] and ASEAN,[67] that were founded for other purposes are now finding it within their mandate to consider the impact of climate change on their members. This localization of focus translates into policy decisions that increase local adaptation and mitigation efforts. Unlike in the second "moment" where

64. *See generally* Kumar et al., *Regional and Seasonal Intercomparison of CMIP3 and CMIP5 Climate Model Ensembles for Temperature and Precipitation*, 42 CLIMATE DYNAMICS (forthcoming 2014).

65. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *Summary for Policymakers*, *in* CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY 10 (2014), http://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf.

66. APEC was established "to support sustainable economic growth and prosperity in the Asia-Pacific region." *About APEC: Mission Statement*, ASIA-PACIFIC ECON. COOPERATION, http://www.apec.org/About-Us/About-APEC/Mission-Statement.aspx (last visited Apr. 27, 2014). The organization's Emergency Preparedness initiative aims "to better prepare for and respond to emergencies and [weather-related] disasters by helping to reduce the risk of disasters and building business and community resilience." *Emergency Preparedness*, ASIA-PACIFIC ECON. COOPERATION, http://www.apec.org/Home/Groups/SOM-Steering-Committee-on-Economic-and-Technical-Cooperation/Working-Groups/Emergency-Preparedness.aspx (last visited Apr. 27, 2014).

67. ASEAN has committed to encouraging its member states to support and participate in the UNFCCC. *ASEAN Leaders' Statement on Climate Change to the 17th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) and the 7th Session of the Conference of Parties Serving as the Meeting of Parties to the Kyoto Protocol*, ASEAN (Nov. 17, 2011), http://environment.asean.org/wp-content/uploads/2012/11/ASEAN_Leaders_Statement_on_Climate_Change.pdf.

action (and hence cost) was apportioned to causation, the burden of intervention seems to be displaced to the place where the harm is, or will be, felt. In this type of governance intervention, there may be a lower collective action problem, because there are fewer actors to coordinate and they tend to be a more homogenous constituency with a direct interest. The move away from a single, global regulatory framework also allows for diverse regulatory experimentation. However, a drawback of local or regional-based regulatory models is that they most likely mean that the costs will be left for the local or regional groups to bear, regardless of who is responsible for the harm.

The implications of this third regulatory model in the extreme weather events context are also problematic. While policy-makers might be better able and willing to act at the local or regional scale, the scientific modeling capability is much more limited and uncertain. This regulatory approach requires a more accurate scientific understanding of the localization of the harm, rather than the cause of the harm in the previous moment. With respect to modeling of extreme weather events, this is a major challenge.

Overall then, the three regulatory models for climate change have all been fraught with failure, but most critically for extreme weather events management, they can be read as a roadmap of the policy challenges in this field. Reactive regulation in the face of harm (first "moment") does not facilitate prevention; apportionment of responsibility to emissions (second "moment") requires a causation link between emissions and extreme events and requires participation of all major emitters; local adaptation and mitigation (third "moment") burdens the affected local communities and gives no leverage to stem the root cause of climate change at the global level. The following Section attempts to model the dilemmas of policy-making for extreme climate events in the face of collective action and scientific uncertainty at various geographic scales.

D. *Collective Action, Scientific Uncertainty, and Geographic Scale: A Triangle of Impossibilities?*

Schiermeier recently highlighted the scope and nature of scientific uncertainty in the field.[68] He argued that while anthropogenic global warming may be scientifically well established, "[t]he sad truth of climate science is that the most crucial information is the least reliable."[69] The gaps highlighted in the article include our inability to project at (high-resolution) scales relevant for decision-makers, lack of understanding of precipitation processes, inadequate understanding of the impacts of aerosols, and the lingering controversies in reconstructions of historical millennial scale climate change from proxy records.[70] In 2012, the IPCC's Special Report on Extremes (SREX) noted the high degree of uncertainty with precise projections and locations of extreme weather or hydrological events related to climate change.[71] Growing heat waves and heavy precipitation events have been statistically related to human-induced warming at aggregate scales for a while.[72] Emerging literature has highlighted the possibility of exacerbating droughts[73] and an increase in the more intense tropical cyclones[74] with climate change, despite remaining uncertainties.[75] There have even been occasional attempts to attribute specific regional and seasonal extreme events to anthropogenic global warming; however, such attempts continue to be fraught with uncertainties.[76]

While promising in terms of decreased collective action problems, local or regional regulatory intervention will have

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68. Quirin Schiermeier, *The Real Holes in Climate Science*, 463 NATURE 284, 284 (2010).

69. *Id.*

70. *See id.* at 284-87.

71. SREX Report, *supra* note 1, at 130.

72. *Id.* at 141-43.

73. *Id.* at 13.

74. *Id.* at 9.

75. *Id.* at 130.

76. *Id.* at 127.

to contend with dramatically more scientific uncertainty regarding the location and extent of extreme weather events. This is important in light of the fact that most regulatory interventions include a cost-benefit analysis.[77] It may be that once uncertainty is factored in, the cost-benefit analysis of intervention at the local scale will never support preventive intervention. Put simply, a cost-benefit based regulatory approach means that if there is no real understanding of the probability that the next tsunami will hit a particular coastal town, then it may not be worthwhile to erect sea defenses in that locality, compared to the cost of rebuilding after the fact in the place where the damage actually occurred.

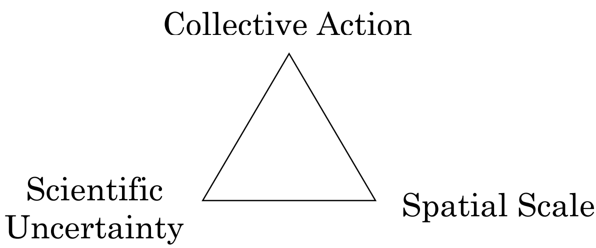

Figure 1. Extreme Weather Events Triangle of Impossibilities

To this day, it seems that most policy interventions have failed or are likely to fail because of what we could term a triangle of impossibilities specific to extreme weather events (Figure 1). For a given geographic scale, scientific uncertainty and collective action problems are in an inverse relationship. At the scale where there is the most scientific certainty, the collective action problem is at its peak, likely defeating any attempt at effective international disciplines. At the local scale where policies are more likely to be implemented, scientific uncertainty regarding extreme weather events is at its maximum, such that it will be difficult for policy-makers to rely on scientific models (Table

77. *See, e.g.*, Exec. Order No. 13563, 76 Fed. Reg. 3821, 3821 (Jan. 12, 2011); NICK HANLEY & CLIVE L. SPASH, COST-BENEFIT ANALYSIS AND THE ENVIRONMENT 4-7 (1993).

1). This would suggest that any regulatory intervention that is preventative or anticipatory would be doomed to fail, and that policy-makers may at best only be able to engage in remediation efforts. If that is true, the lessons for policy-makers are that remediation is their best alternative to a negotiated agreement. It may be, though, that another generation of regulatory tools could help overcome the triangle of impossibilities. Through a combination of empirical examples and theoretical analysis, the next Part offers some proposals for such regulatory devices.

Spatial Scale for Policy Intervention	**Scientific Uncertainty Regarding Occurrence of Extreme Weather Events**	**Collective Action Problem for Multi Actor Coordination**	**Extreme Weather Event Policy-Making Challenges**
Local	Highest	Lowest	- High degree of scientific uncertainty regarding events tends to hinder policy intervention - Policy intervention at the local level may have low effectiveness (local prevention and remediation only)
Regional/ Continental	High	Variable/High	- Increased number and types of actors makes coordination difficult - Regional climate modeling remains highly uncertain
Global	Lowest	Highest	- Cost of actor coordination is high; inertia and free-rider incentives makes coordination extremely difficult - Lowest level of scientific uncertainty is helpful on aggregate but aggregate models make it difficult to identify specific meaningful interventions

Table 1. Relationship Between the Triangle of Impossibilities Variables and Policy-Making for Extreme Weather Events

II. OVERCOMING THE TRIANGLE OF IMPOSSIBILITIES

If the triangle of impossibilities identified in the first part of this Article is truly an impediment to policy-making, then we must explore what policies might be effective with only two sides of the triangle. Policy interventions in recent decades have taken several approaches to try to overcome the international collective action problem that plagues global climate change efforts. The success of these policies can be analyzed with regard to how important scientific certainty is to the type of policy developed and the scale at which the policy is implemented. Interventions have failed even when scientific uncertainty is irrelevant, partially due to a collective action problem. By contrast, some interventions that rely on a lot of "uncertain science" are successful when developed and implemented at a smaller scale. A marriage of the "right" amount of reliance on science aimed at the appropriate level of spatial scale might allow policy-makers to transcend the collective action dilemma and respond more effectively to the challenge of extreme weather events.

This Part presents a number of policies, successful and unsuccessful, their implementation on a global or local scale, and their reliance on scientific principles developed in the field of climate change. Section A examines the successes and shortcomings of multi-scale intervention in the face of scientific uncertainty. Section B assesses the potential of low collective action interventions at the local scale. Section C identifies how the issue of scale could be overcome, despite increased collective action problems.

A. *Overcoming Collective Action Problems: Multi-Scale Intervention in the Face of Scientific Uncertainty*

In this Section, we focus on policies that might be implemented at the local and global scale, taking into account the relative scientific uncertainty at the global and local scales. The objective is to overcome the issue arising from the third side of the triangle, the collective action problem, which is more acute at the more global scale. Such a scenario is illustrated by the Kyoto Protocol, which will be remembered for failing to meet its emissions targets.[78] Even though the agreement was signed by many countries, the United States, China, and India—three of the largest GHG emitters—did not ratify the Protocol or make emissions commitments under it.[79] As a result, global emissions have continued to rise, eventually crossing the "historic threshold" of 400 ppm CO_2 and entering into a "new danger zone."[80] Failure to bind these important countries is a prime example of the collective action problem at the global scale and its effect on climate change and extreme weather events.[81] The failure of global efforts to curb emissions has two sets of implications for extreme weather events. First, it means that climate change will continue to progress and with it the increased frequency and magnitude of extreme events.[82] Regulatory interventions would therefore be displaced from a general attempt at managing climate change to a more focused effort to manage the impacts of extreme weather events. Second, it means that the regulatory model of global apportioned commitments is not effective and that coordinated efforts to tackle the cost and damages resulting from extreme events should be framed differently.[83] Each issue is addressed in more detail in this Section.

1. Decoupling Extreme Weather Events Management from Climate Change Regulation

While the discourse of climate change remains somewhat of a political lightning rod, the localized and more immediately visible impact of extreme weather events may make it politically more likely to seek an effective response.

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78. Gwyn Prins & Steve Rayner, *The Kyoto Protocol*, 64 BULL. ATOMIC SCIENTISTS 45, 45 (2008).

79. *Id.* at 47-48.

80. Christiana Figueres, Exec. Sec'y, Statement by UNFCCC Executive Secretary on Crossing of 400 ppm CO2 Threshold (May 31, 2013), *available at* http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/400_ppm_media_alert_13052013.pdf.

81. Prins & Rayner, *supra* note 78, at 46.

82. *See id.* at 45-46.

83. *See id.*

The fact that modeling of extreme weather events at the local scale is still quite imprecise does not seem to have gained much traction in the face of uncontestable damage from events such as hurricanes and floods. In other words, the political and psychological importance of scientific uncertainty with respect to climate change more generally seems to recede in the face of actual local extreme weather events. Indeed, a recent study published in *Nature Climate Change* found that "individuals who have direct experience of phenomena that may be linked to climate change [are] more likely to be concerned by the issue."[84]

Resiliency (with respect to floods, droughts, energy, etc.) has been adopted as a call word across the political spectrum and has been readily embraced by policy-makers.[85] In the United States, efforts to adapt to what officials are calling a "new normal" climate took center stage in a 2012 U.S. Senate hearing on climate change, which was the first of its type in two and a half years.[86] Journalists have noted that extreme weather has the potential to renew a conversation on climate change and gain political traction because of the necessity to create policies around it, which may include changing

84. Alexa Spence et al., *Perceptions of Climate Change and Willingness to Save Energy Related to Flood Experience*, 1 NATURE CLIMATE CHANGE 46, 46 (2011), *available at* http://www.nature.com/nclimate/journal/v1/n1/full/nclimate 1059.html.

85. *See Extreme Weather Events: The Cost of Not Being Prepared: Hearing Before the Comm. on Homeland Sec. and Governmental Aff.*, 113th Cong. (2014) (joint statement David Heyman, Assistant Secretary, Office of Policy, Dep't of Homeland Sec. & Caitlin Durkovich, Assistant Secretary, Office of Infrastructure Prot., Nat'l Prot. & Programs Directorate, Dep't of Homeland Sec.); Press Release, White House Office of the Press Sec'y, Exec. Order – Preparing the U.S. for the Impacts of Climate Change (Nov. 1, 2013) (on file with author); Amy Harder & Coral Davenport, *Climate-Change Debate Aside, Sandy Inspires 'Resiliency Planning' for Extreme Weather*, NAT'L J. (Oct 31. 2012), http://www.nationaljournal.com/energy/climate-change-debate-aside-sandy-inspires-resiliency-planning-for-extreme-weather-20121031.

86. *Update on the Latest Climate Change Science and Local Adaptation Measures Before S. Comm. On Env't & Pub. Works*, 112th Cong. (2012), *available at* http://www.epw.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing& Hearing_ID=c0293eca-802a-23ad-4706-02abdbf7f7c3.

building codes in flood plains and on shorelines, constructing offshore wind turbines, and managing suburban sprawl.[87]

And it has. In 2012, the devastation from a succession of extreme events and breaking climate records gave U.S. policy-makers and the public pause, generating a fresh interest in not only addressing climate change, but also in adopting critical resilience and adaptability measures at the state and national level.[88] Although Democrats and Republicans in Congress may not always agree on GHG emissions, they do share a concern about the need for climate change adaptation at the local level, evidenced by a Senate resolution introduced in January that calls for lawmakers to "prepare and protect communities" from extreme weather.[89] A recent editorial written by former EPA leaders illustrates this point. Ruckelshaus, Thomas, Reilly, and Todd, all administrators of the EPA under Republican presidents, wrote that the United States must transcend political affiliation and take substantial steps to curb climate change and "start the overdue debate about what bigger steps are needed and how to achieve them—domestically and internationally."[90]

Decoupling the politics of extreme weather events from those of climate change also allows the discourse on extreme weather events to be somewhat freer from the politicized uncertainties and public misunderstandings relating to the science of climate change. This may provide support for a broader based climate change policy intervention that is initially positioned in relation to extreme weather events. In other words, even though the science indicates that anthropogenic climate change is a causal factor in the

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87. Scott Dance, *Severe Weather Renews Climate-Change Talks in Washington, Annapolis*, THE BALTIMORE SUN (Aug. 2, 2012), http://articles.baltimoresun.com/2012-08-02/news/bs-md-climate-change-20120801_1_climate-change-climate-change-talks-severe-weather.

88. Sarah Kellogg, *The Cost of Doing Nothing*, 27 WASH. LAW. (May 2013), http://www.dcbar.org/bar-resources/publications/washington-lawyer/articles/may-2013-hurrican-cost.cfm.

89. *Id.*

90. William D. Ruckelshaus et al., Op-Ed, *A Republican Case for Climate Action*, N.Y. TIMES, Aug. 2, 2013, at A21.

increase in extreme weather events (which can be viewed as a top down relationship), it may be easier to build policies around a bottom-up approach that starts with a focus on extreme events and grows to involve broader climate-change and emissions reduction interventions. For instance, the recent study in *Nature Climate Change* linked flooding experience to lower levels of uncertainty regarding climate change.[91] As some commentators note, "[d]isasters often highlight the need for a well-functioning, well-funded government, and extreme weather events help make the case that rising global temperatures really do have catastrophic effects on all of us."[92] This catastrophic effect may create the political pressure needed to force policy-makers to address the effects of extreme weather and eventually the anthropogenic causes of climate change.

Another important consideration is financial resources. While state and local budgets may not offer much for curbing climate change, where costs and benefits are diffuse, resiliency of specific communities and infrastructure may be a much more tangible objective. Such is the goal of the Asian Cities Climate Change Resilience Network (ACCCRN), an organization funded by the Rockefeller Foundation, which experiments with a range of activities that will collectively improve the ability of the ten participating cities to withstand, to prepare for, and to recover from the projected impacts of climate change.[93] Similar to ACCCRN, the Institute for Social and Environmental Transition-International (ISET) "has worked with stakeholders in [fifteen] cities in [five] countries . . . to identify the challenges climate change will pose for these cities and to begin the process of systematically building city resilience to climate change in the face of those challenges."[94] ISET's process

91. Spence et al., *supra* note 84, at 47-48.

92. Ben Cohen, *Dear Liberals, Please Don't Politicize the Oklahoma Tornado*, THE DAILY BANTER (May 21, 2013), http://thedailybanter.com/2013/05/dear-liberals-please-dont-politicize-the-oklahoma-tornado.

93. *Participating Countries*, ASIAN CITIES CLIMATE CHANGE RESILIENCE NETWORK, http://www.acccrn.org/about-acccrn/participating-countries (last visited Apr. 27, 2014).

94. Karen MacClune & Sarah Optiz-Stapleton, *Building Urban Resilience to Climate Change: What Works Where, and Why,* INSTITUTE FOR SOCIAL AND

includes the development and refining of a "resilience-building curriculum that includes laying the groundwork for addressing climate change and climate resilience, conducting a climate change vulnerability and risk assessment, and using this assessment and other materials to prepare an initial resilience strategy."[95]

The costs of rebuilding public and private infrastructure after a tornado or flood are much easier to assess than the creeping damage of desertification. Crops destroyed by drought and spikes in food prices due to the ensuing shortages are also readily ascertainable. Hence, inasmuch as environmental policies world-wide remain based on traditional short- and medium-term cost-benefit analysis, focusing on extreme weather events as an entry point for climate change policy-making may give policy-makers more political traction than tackling the broader problem of climate change directly.

While some of the scale and uncertainty problems of climate change might be lesser impediments to responding to extreme weather events disasters, the issue remains that scientific models are not likely to give reliable predictions regarding the location of disasters.[96] As such, it puts policy-makers largely in an ex-post responsiveness mode, rather than in a preventive mode. Because the risk and scope of future damages are difficult to assess, making a cost-benefit analysis may be impossible. Therefore, it may be that there is still a need for a national or supranational regulatory process to assist particular communities with the cost and response to extreme weather events. The following Section explores the possibility of coordination in the extreme weather events space.

2. Global Policy Coordination: A Doomed Enterprise?

While some countries may be adequately equipped to respond to extreme weather events, a number of developing countries, in particular, are much more vulnerable. While

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ENVIRONMENTAL TRANSITION (2012), http://www.i-s-e-t.org/images/pdfs/iset_buildingurbanresiliencetoclimatechange_120831.pdf.

95. *Id.*

96. SREX Report, *supra* note 1, at 19, 47-48.

Hurricanes Katrina in 2005 and Sandy in 2012, in the Gulf Coast and the East Coast of the United States, respectively, did not require international intervention, the extreme flooding in Thailand in 2011, extreme tropical storms in the Caribbean, heavy monsoon rains in 2010 in Pakistan, and the 2008 cyclone that devastated Burma/Myanmar have called for international support to assist in the immediate response as well as in the longer term rebuilding efforts. For instance, United Nations and U.S. agencies provided about $335 million for emergency response and recovery activities after Cyclone Nargis in Burma/Myanmar.[97] Another example of international funding efforts is the $100 million that Congress allocated to the Caribbean countries Grenada, Jamaica, and Haiti after September 2004 Hurricane Ivan and Tropical Storm Jeanne.[98] Recently, the United Nations Climate Conference set up a new international mechanism to help developing countries affected by loss and damage from climate change impacts, such as the Philippines typhoon.[99] The mechanism is "tasked to provide countries with technical support, to facilitate actions and improve coordination of work inside the UN Climate Convention as well as with other organizations" while also "mobalis[ing] and secur[ing] funds, technology and capacity building activities."[100]

For many countries, then, the increased incidence and gravity of extreme weather events related to global climate change cannot be addressed purely locally or even nationally. If the theory of common but differentiated responsibility is to have a bearing on mitigation and adaptation efforts, then states will need to devise international cooperation mechanisms to remedy the harm borne by smaller developing

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97. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-11-700, BURMA: UN AND U.S. AGENCIES ASSISTED CYCLONE VICTIMS IN DIFFICULT ENVIRONMENT, BUT IMPROVED U.S. MONITORING NEEDED (2011).

98. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-06-645, FOREIGN ASSISTANCE: USAID COMPLETED MANY CARIBBEAN DISASTER RECOVERY ACTIVITIES, BUT SEVERAL CHALLENGES HAMPERED EFFORTS (2006).

99. Martin Kohr, *Outcome of UN Climate Conference in Warsaw (COP19)*, SOUTHNEWS (Nov. 26, 2013), http://us5.campaign-archive2.com/?u=fa9cf38799136b5660f367ba6&id=8ca0a80f6c&e=[UNIQID].

100. *Id.*

states that contributed the least to climate change but are also the least able to cope with its consequences. The plight of Pacific island states that are likely to become inhabitable in less than fifty years due to the rise of sea levels has been well publicized, though no solution has emerged yet regarding the potential relocation of their population and future of their statehood.[101] Short of that, it is likely that these particularly vulnerable states would be jeopardized by severe weather events even before the rise in sea levels becomes the primary issue.[102]

International coordination is necessary for two important reasons. The first is financial. In order to fund the roughly $5 trillion investment that the International Energy Agency reports will be necessary to achieve climate goals by 2020, it is necessary that the international community work together to finance this investment.[103] Although some financing comes by way of official development assistance and private investment, these funds are voluntary and fall short of the needs.[104] The second reason is the peace and security issues that may arise when the threats of climate change become a reality. These possibilities were illustrated in a simulation "war game" orchestrated by the Center for a New American Security, which was intended to explore the national security consequences of climate change and the likely challenges the world faces, such as mass migration, an increased incidence of intense storms, high risk of conflict, and low capacity for cross-border cooperation.[105]

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101. Julia Pyper & ClimateWire, *Storm Surges, Rising Seas Could Doom Pacific Islands This Century*, SCI. AM. (Apr. 12, 2013), http://www.scientificamerican.com/article/storm-surges-rising-seas-could-doom-pacific-islands-this-century.

102. *Id.*

103. Alex Morales, *Climate Goals Require $5 Trillion Investment by 2020*, BLOOMBERG (Apr. 25, 2012), http://www.bloomberg.com/news/2012-04-25/climate-goals-require-5-trillion-investment-by-2020.html.

104. *The Global Climate Change Regime*, COUNCIL ON FOREIGN RELATIONS (June 19, 2013), http://www.cfr.org/climate-change/global-climate-change-regime/p21831.

105. Sharon Burke & Christine Parthemore, *Climate Change War Game: Major Findings and Background* (Ctr. For a New Am. Sec. Working Paper, 2009),

The issue then is whether any sort of international coordination is a realistic prospect in the face of the failure of the Kyoto Protocol (discussed above) and other schemes such as the Convention to Combat Desertification.[106] More positive examples such as the Montreal Protocol may provide some cause for optimism.[107] Would an international attempt to coordinate with respect to extreme weather events be more like the former or the latter?

Despite its wide ratification (195 state parties), the 1994 Convention to Combat Desertification (UNCCD) involved mostly aspirational and hortatory provisions, calling for cooperation and technology transfer from industrialized countries much as a framework convention would do.[108] The ten-year strategy for implementation of the UNCCD involved scientific collaboration around agreed themes and support to impact the monitoring and reporting under the UNCCD system, active influencing of relevant international, national, and local processes and actors, identifying and taking action on interlinkages of selected key themes, joint activities by the secretariats of three "sister Conventions," and online tools and information on capacity building.[109] Although the UNCCD specifically targets the three known factors causing a lack of progress in addressing desertification (inadequate focus on indirect drivers, inadequate funding, and an absence of effective domestic policies), and the international normative infrastructure is very much in place, "the words belie the lack of action."[110] As Tal observes, "[d]espite the intentions and rhetoric [of going beyond direct physical causes and confronting the indirect drivers of

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http://www.cnas.org/files/documents/publications/Climate_War_Game_Working %20Paper_0.pdf.

106. *See* Prins & Rayner, *supra* note 78, at 45; Alon Tal, *Degraded Commitments: Reviving International Efforts to Combat Desertification*, 13 BROWN J. WORLD AFF. 187, 189 (2007) and accompanying footnotes.

107. Harris, *supra* note 18, at 204-05 and accompanying footnotes.

108. Convention to Combat Desertification, *supra* note 29, arts. 9-21.

109. *Key Topics*, UNITED NATIONS CONVENTION TO COMBAT DESERTIFICATION, (last visited Apr. 27, 2014), http://www.unccd.int/en/programmes/Pages/ home.aspx.

110. Tal, *supra* note 106, at 189.

desertification], in practice the UNCCD has done little if anything to direct the attention of its member nations to interventions that might address deeper sociological factors."[111]

On the other hand, the Montreal Protocol has been effective at reducing and reversing the ozone layer depletion.[112] In this instance, scientists were able to forecast that ozone depletion could be reversed and reduced, with the stratospheric ozone layer expected to recover over the next fifty years or so.[113] Harris notes that the Montreal Protocol was successful in part because it contains requisites for collective action discussed by Olson, especially selective incentives or side-payments, and also because it incorporated Olson's theory of small group committees.[114] Benedick and Haas give much credit to scientists who were active in workshops, conferences, and consultations that laid the foundation for the eventual international consensus.[115] In particular, Benedick believed it was thanks to this "[c]lose collaboration between scientists and key government officials who became convinced of the long-term dangers," despite there still being considerable uncertainty about the full nature of the problem, that a coordinated response "ultimately prevailed over more parochial and short-run interests of national politicians."[116]

One possibility for international cooperation would be to create a global insurance fund to help compensate for the damage resulting from extreme weather events and engage in preparation and prevention policies. The insurance mechanism could also include a knowledge repository function, to collect best practices and other information relating to the impact and adequacy of various policies. In

111. *Id.*

112. Harris, *supra* note 18, at 204-05.

113. *Id.*

114. *See id.* at 205, 209.

115. *See id.* at 208.

116. Richard E. Benedick, *Protecting the Ozone Layer: New Directions in Diplomacy*, *in* PRESERVING THE GLOBAL ENVIRONMENT 112, 144 (Jessica Tuchman Mathews ed., 1991).

deploying the insurance funds, the organization could include an advisory function to assist states in choosing policy responses that are most appropriate. The advantage of such a system is that it is not contingent on reducing the scientific uncertainty regarding the location or risk of incidence of a particular adverse event and could rely instead on the available global data on extreme events projections to determine how much the fund should be capitalized. In practice, private insurers and some NGOs are already working to incorporate risks related to climate change in insurance strategies.[117]

The idea of an insurance fund is inspired by Rawls' theory of social justice, where actors make decisions under a veil of ignorance because they do not know what their lot will be and therefore they all attempt to minimize the worst lot, as they might be the recipients of it.[118] The analogy is limited by the fact that policy-makers in fact do have some knowledge about their state's vulnerability to extreme weather events, but they cannot be sure of their ability to cope with future harm. Even in the United States, a more vulnerable state like Louisiana was not able to address the damage from an extreme event such as Hurricane Katrina and cannot be sure that federal resources will be available in the future to support it. As such, the veil of ignorance still largely stands.

Mechanisms for funding such an insurance fund could be drawn from other successful instruments. Funding contributions could be proportionate to historic emissions (common but differentiated responsibility principle) and current emissions (polluter-pays principle) such as the Gas Guzzler Tax[119] or Superfund Law[120] in the United States. Another funding allocation may be apportionment to a country's economic size, as used by the Organization for Economic Co-operation and Development and the

117. *See, e.g.*, CLIMATEWISE, http://www.climatewise.org.uk (last visited Apr. 27, 2014).

118. *See* JOHN RAWLS, A THEORY OF JUSTICE 136-40 (Harvard Univ. Press 1971).

119. Gas Guzzler Tax, 26 U.S.C.A. § 4064 (2005).

120. Hazardous Substance Superfund, 26 U.S.C.A. § 9507 (1986).

International Monetary Fund.[121] These organizations act like credit unions and fund their budgets by collecting resources from their member countries in quota subscriptions, or membership fees.[122] Funding could also be drawn in the manner of investments and lending, such as the World Bank, which offers its member nations equity shares in the Bank.[123] Finally, a financial mechanism such as the GEF Trust Fund, which seeks voluntarily committed funds, may be employed to serve as the controller of donations collected from donor countries, international organizations, civil society organizations, and the private sector.[124] Replenishment of the Trust Fund takes place every four years based on donor pledges that are funded over a four-year period.[125]

B. *Overcoming Scientific Uncertainty: Low Collective Action Interventions at the Local Scale*

In this Section, we focus on policies that might be implemented at the local or regional scale, but that have an impact at a more global scale. Collective action is less of an issue since the intervention is more local, so both the scale and collective action sides of the triangle are satisfied. The objective is to overcome the issue arising from the third side of the triangle, the scientific uncertainty, which is most prevalent at the local scale.

Many theorists agree that knowledge is an important part of cooperation.[126] The collective action theory goes as far

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121. *See* Articles of Agreement of the International Monetary Fund art. III, Dec. 27, 1945, 60 Stat. 1401 (current version at 15 I.L.M. 546, 547 (Apr. 30, 1976)).

122. David Driscoll, *The IMF and the World Bank: How Do They Differ?*, INT'L MONETARY FUND, http://www.imf.org/external/pubs/ft/exrp/differ/differ.htm (last updated Aug. 1996); *see also Budget*, ORG. FOR ECON. CO-OPERATION & DEV., http://www.oecd.org/about/budget (last visited Apr. 27, 2014).

123. Driscoll, *supra* note 122.

124. *GEF-Administered Trust Funds*, GLOBAL ENVIRONMENT FACILITY, http://www.thegef.org/gef/trust_funds (last visited Apr. 27, 2014).

125. *Id.*

126. *See* RUSSELL HARDIN, COLLECTIVE ACTION 182 (1982); Harris, *supra* note 18, at 204; *see generally* ROBERT O. KEOHANE, AFTER HEGEMONY: COOPERATION AND DISCORD IN THE WORLD POLITICAL ECONOMY (1984); OLSON, *supra* note 16.

as suggesting that information is essential to increase the likelihood of effective international collective action.[127] According to Hardin, "[t]he degree of cooperation may depend on the quality of knowledge generally available."[128] Information proved to be a critical factor in the creation of the Med Plan cleanup and the Montreal Protocol ozone-protection regime, and it is proving to be even more critical for climate change.[129] The issue with extreme climate events is the vast scientific uncertainty at the more local scales, the fact that such uncertainty may be intractable barring some unforeseeable major physics breakthrough, and the epistemic difficulty in apportioning the role of climate change to particular extreme weather events.

1. Lessons from Domestic Regulation: Successes in Ecosystem Management

Ecosystem management, proposed as the modern and preferred way of managing natural resources in the United States, is "driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on [the] best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function."[130]

The conventional strategy of ecosystem management is to act when there is reasonable certainty of what the effects will be, and then adopt rules based on the current understanding.[131] This approach often focuses on maximizing short-term yield and economic gain, while trying to overcome obstacles including inadequate information, the openness and interconnectedness of ecosystems on scales that transcend management boundaries, widespread ignorance of the function and dynamics of ecosystems, and the prevailing

127. *See* Harris, *supra* note 18, at 223.

128. *Id.* at 204 (quoting HARDIN, *supra* note 126, at 182).

129. *Id.*

130. Norman L. Christensen et al., *The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management,* 6 ECOLOGICAL APPLICATIONS 665, 665 (1996).

131. Karkkainen, *supra* note 13, at 201.

public perception that immediate economic and social value outweigh the risk of future ecosystem damage.[132] Many scholars believe that this strategy "is a prescription for inaction and ineffectiveness, or policy failure."[133]

By contrast, some scholars are recognizing the need for an integrated, holistic management of ecosystems, which takes into account questions of scale and involves "continuous experimentation and dynamic adjustment in response to new learning."[134] These models usually include "hybrid public-private governance structures, emphasizing broad information-sharing, systematic performance monitoring, and collaborative problem-solving among parties representing diverse interests at multiple, nested spatial scales . . . ."[135]

Efforts like the Chesapeake Bay Program[136] and the South Florida Ecosystem Restoration Project[137] are examples

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132. Christensen et al., *supra* note 130, at 665.

133. Karkkainen, *supra* note 13, at 201; *see* Frampton, *supra* note 15, at 42-46; Oran R. Young, *Institutional Interplay: The Environmental Consequences of Cross-Scale Interactions*, *in* THE DRAMA OF THE COMMONS, 263, 263-66 (Elinor Ostrom et al. eds., 2002).

134. Karkkainen, *supra* note 13, at 193; *see generally* Oliver A. Houck, *TMDLs IV: The Final Frontier*, 29 ELR 10,469 (1999).

135. Karkkainen, *supra* note 13, at 193-94.

136. In the Chesapeake Bay Program, the Chesapeake Bay Commission, the coordinating group for the Maryland, Virginia and Pennsylvania legislatures, was a founding member and remains a leading participant in the Chesapeake Executive Council, the central coordinating institution that also includes top state and federal executive branch authorities. Collaborative agreements reached through this region-wide coordinating mechanism inform and constrain the legislative agendas in each of the state legislatures, even as they inform and constrain the executive branch's exercise of a wide range of discretionary executive and administrative powers. *See, e.g.*, CHESAPEAKE 2000, http://www.chesapeakebay.net/content/publications/cbp_12081.pdf (last visited Apr. 27, 2014).

137. In the Water Resources Development Act of 1996, Congress established the South Florida Ecosystem Restoration Task Force, which consists of fourteen members "who coordinate the development of consistent policies, strategies, plans, programs, projects, activities, and priorities addressing the restoration, preservation, and protection of the South Florida ecosystem." The Task Force writes annual reports, which provides the basis for ecosystem management and the integration of management across scales and entities. *See About Us*, U.S. DOI OFFICE OF EVERGLADES RESTORATION INITIATIVES, SOUTH FLORIDA ECOSYSTEM

of "large regional or 'landscape' scale ecosystem management efforts" that showcase the success and adaptability of diverse experimentation.[138] These complex and hybrid governance structures tend to involve "high levels of both vertical, horizontal, and functional coordination" across federal-state-local tiers of government, agencies, and non-governmental parties.[139]

Some lessons can be adapted to policy-making on extreme weather events based on the success of these approaches to ecosystem management. By integrating scales, international efforts can "pool[] a richly diverse mix of policy relevant information derived from various angles of vision [local to global], and reflecting various degrees of resolution."[140] Because of the hybrid governance structure, there is tremendous opportunity for "pooling a rich and diverse array of resources and capacities" (financial, expertise, etc.) under a "single institutional umbrella, [which] frequently finds expression in the form of frequent face-to-face interactions, combined databases and electronic information management systems, and regular . . . interdepartmental working relationships."[141] Although an idealized construction, this collaborative regime certainly holds distinct advantages over conventional rivals as a mechanism for tackling the complexities and cross-border nature of climate change.[142] By adopting these integrated strategies to the global policy sphere, policy-makers and scientists may find greater synergisms between issues of spatial scale, collective action, and scientific uncertainty.

RESTORATION TASK FORCE, http://www.sfrestore.org/about_us.html (last visited Apr. 27, 2014); *see also South Florida Ecosystem Restoration: Scientific Information Needs*, SOUTH FLORIDA INFORMATION ACCESS (Carole Goodyear ed., 1996), *available at* http://sofia.usgs.gov/publications/reports/sci_info_needs/#full.

138. Karkkainen, *supra* note 13, at 210.

139. *Id.* at 226.

140. *Id.* at 223.

141. *Id.* at 219.

142. *Id.*

2. Local Intervention in the Face of Scientific Uncertainty? Some Successes

In the extreme weather events context, the increased uncertainty at the local level is very high, yet a number of local public and private actors have attempted to implement prevention and remediation schemes in the face of inaction at the national or international levels. One such example is the initiative undertaken by a farming community in Rajasthan (India) to curb the impacts of extreme weather.

Farmers in the Rajasthan region reported experiencing changes in terms of increasing temperatures and decreasing precipitation during the monsoon season.[143] Because the community's livelihood was at stake, farmers were unable to wait for implementation of a national mitigation strategy to heed the effects of climate change.[144] In response, farmers implemented several sustainable farming practices such as using more drought-resistant indigenous seeds rather than hybrid seeds, shifting crop patterns to species requiring less water, shifting sowing periods according to the weather, reintroducing native drought-resistant grasses for pasturing, and employing sustainable water management techniques.[145]

The project is a remarkable example of how small-scale techniques can benefit a whole village, even in the face of erratic and undependable weather. A major part of the success of these small-scale applications is due to the preliminary work of the village committee, allowing for well-directed interventions and less dependency on high cost inputs and increased reliance on locally available resources.[146]

A higher-level policy intervention would be to collect the data regarding such local interventions and create a repository that can be accessed by others facing similar

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143. Poonam Pande, *Adaptation of Small Scale Farmers to Climatic Risks in India* 20-21 (Sustainet India 2005), http://www.sustainet.org/download/Adaptation-in-India_long.pdf.

144. *Id.* at 25-26.

145. *Id.* at 26-29.

146. Kaspar Akermann, *How do Farmers Respond to Climate Change in Rajasthan?*, 43 RURAL 21, 30, 32 (Apr. 2009), *available at* http://www.rural21.com/uploads/media/R21_How_do_small_farmers_respond..._0409.pdf.

constraints. Rather than simply narrative case studies, the resource could take the form of a searchable database that organizes human activities and inputs based on their resistance or vulnerability to particular types of extreme events. This would be useful for multilateral development agencies, which could act as the knowledge dissemination vector to assist local communities in devising effective policies responding to their specific needs and conditions.

3. Local Interventions that Scale Up?

Because of the scientific uncertainty at increasingly granular scales, local interventions might be most effective if they are capable of having an impact beyond the local. Policy interventions might be easier to implement locally because of the reduced collective action problem, but because the extreme weather events might happen elsewhere, some scaling up in the impact of the intervention would increase the policy's effectiveness.

In the climate change context, the European Union (EU) airline emissions trading scheme[147] is an example of such an intervention. Aviation contributes to climate change at regional and global scales through a variety of emissions, including carbon dioxide, nitrogen oxides, water vapor, particulate matter, and other pollutants.[148]

Because a significant part of the world's aviation transits, originates, or arrives in the EU, the group has the capacity to have an impact on world aviation policy and emissions in that sector by acting unilaterally. As a politically integrated unit, the EU has lower collective action problems compared to what a global negotiation on this issue would face. Since aviation emissions have an impact beyond the EU borders, a local intervention may have an impact at

147. *EU ETS & Aviation*, INT'L EMISSIONS TRADING ASS'N 1 (Jan. 18, 2012), http://www.ieta.org/index.php?option=com_content&view=article&id=446:eu-ets--aviation&catid=54:3-minute-briefing&Itemid=135.

148. *See also* A. Mahashabde et al., *Assessing the Environmental Impacts of Aircraft Noise and Emissions*, 47 PROGRESS IN AEROSPACE SCI. 15, 19-21 (2011); *see generally* David S. Lee et al., *Transport Impacts on Atmosphere and Climate: Aviation*, 44 ATMOSPHERIC ENV'T 4678 (2010).

the global scale. In this case, the scientific understanding of airline emissions and their impact is developing, but the uncertainty is still very high in existing models.[149]

Unfortunately, the scheme has now become mired in international discussions as the United States and China, in particular, have threatened the EU with retaliatory action if the latter was to implement the scheme unilaterally.[150] In response, the EU froze for one year its rule that all airlines must pay for their carbon emissions for flights into and out of EU airports in an effort to create a positive atmosphere for international talks on an alternative global plan to tackle airline emissions.[151] The reimplementation of the scheme on all flights passing through Europe is still contentious, as the cost for U.S. airlines would be about $3.1 billion through 2020.[152] Despite technological advances to reduce airline emissions, European officials assert that a market-based system such as the emissions trading scheme is necessary to create an incentive for airlines to curb their emissions.[153]

This scenario illustrates how a unilateral intervention by a critical mass player can have effects beyond that player. The collective action problem is reduced, but unlike in the local mitigation efforts discussed above (farming in Rajasthan), the positive impact in reduction and mitigation would be global. The risk posed by unilateralism, however, is illustrated by the backlash against the EU's decision on airline emissions and the whole scheme is now at risk of being lost in the collective action quagmire. In cases where the spillover effects for third parties are not only positive

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149. Nicholas W. Simone, Marc E.J. Stettler & Steven R.H. Barrett, *Rapid Estimation of Global Civil Aviation Emissions with Uncertainty Quantification*, 25 TRANSP. RES. PART D: TRANSP. & ENV'T 33, 33 (Dec. 2013), *available at* http://www.sciencedirect.com/science/article/pii/S1361920913001028#.

150. *EU Suspends Extension of Plane Emissions Trading Rules*, BBC NEWS (Nov. 12, 2012), http://www.bbc.co.uk/news/business-20299388.

151. Barbara Lewis, *EU Commission Freezes Airline Carbon Emissions Law*, REUTERS (Nov. 12, 2012), http://www.reuters.com/article/2012/11/12/eu-airlines-ets-idUSL5E8MCAAY20121112.

152. James Kanter, *E.U. Considers Emission Fines on Chinese and Indian Airlines*, N.Y. TIMES (May 16, 2013), http://www.nytimes.com/2013/05/17/business/global/17iht-emit17.html?pagewanted=all.

153. *Id.*

(reduced emissions), but also negative (costs), pure unilateralism will be harder to implement. Nonetheless, where a state or group of states effectively has a monopoly position (the EU's territory is the monopolistic resource and airlines will still want to have access to it), there will be a greater possibility of obtaining third-party compliance.

C. *Overcoming Scale: Dealing with Scientific Uncertainty and Collective Action*

In the absence of international or statewide regulations, a majority of policy interventions have taken place at a mid-scale level (national or local large region), where both the collective action problem and the scientific uncertainty are reduced. For instance, California or the U.S. Eastern seaboard states face definite vulnerabilities and are able to mobilize political action more easily than at the federal level. The downside of such interventions, however, is that they are typically limited to mitigation and remediation, and typically are at a scale insufficient to affect climate change, a root cause of increased adverse events.

In 2012, India surpassed Russia to become the fourth-leading producer of GHG emissions worldwide, trailing only the EU, China, and the United States.[154] As a nation not bound by emission targets set by the Kyoto protocol, India has taken steps on its own to address the impacts of climate change, especially for those sectors which will be hardest hit by extreme weather events.[155] Although primarily driven by the objective of sustainable livelihood and poverty alleviation, the Indian government is engaged in "[s]everal ongoing efforts to promote sustainable agriculture, forestry and coastal zone development."[156] The 2008 National Action Plan on Climate Change (NAPCC) details the government's official climate strategy, addressing both adaptation and

154. *Global CO2 Emissions Reach Record-High, Driven by Fossil Fuel Use in Rapidly Industrializing Nations*, CLEAN TECHNICA (May 25, 2012), http://cleantechnica.com/2012/05/25/global-co2-emissions-reach-recordhigh-driven-fossil-fuel-use-rapidly-industrializing-nations.

155. Pande, *supra* note 143, at 11-12.

156. *Id.* at 11.

mitigation issues implemented through various institutional mechanisms.[157] The government of India recognized the need for a national strategy to not only adapt to climate change, but to further enhance ecological sustainability as India continues to rapidly develop.[158]

Another example of a mid-scale success is the state of California, which has instituted regional innovative programs administered at the state level. In 2006, California passed AB 32, the Global Warming Solutions Act of 2006, which set the 2020 greenhouse gas emissions reduction goal into law.[159] The Bill "direct[s] the California Air Resources Board (ARB or Board) to begin developing discrete early actions to reduce greenhouse gases while also preparing a scoping plan to identify how best to reach the 2020 limit."[160] Most impressively, AB 32 creates a state-wide GHG cap-and-trade program, which uses market-based mechanisms to lower greenhouse gas emissions.[161] Beginning January 1, 2013, the cap-and-trade rules "apply to large electric power plants and large industrial plants."[162] In 2015, the program will extend to cover nearly eighty-five percent of the state's total greenhouse gas emissions, which will make California's program second in size only to the EU's emissions trading system.[163] California's experience may serve as a crucial indicator as to how an economy-wide cap-and-trade system can function in the United States and potentially globally.[164] Globally, California ranks twelfth to eighteenth in total emissions, depending on sources.[165] Yet, due to its many

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157. *Id.* at 12.

158. *Id.* at 11.

159. *Assembly Bill 32: Global Warming Solutions Act*, CAL. ENVTL. PROT. AGENCY, http://www.arb.ca.gov/cc/ab32/ab32.htm (last visited Apr. 27, 2014).

160. *Id.*

161. *Id.*

162. *California Cap and Trade*, CTR. FOR CLIMATE & ENERGY SOLUTIONS, http://www.c2es.org/us-states-regions/key-legislation/california-cap-trade (last visited Apr. 27, 2014).

163. *Id.*

164. *Id.*

165. *See* James Fine & Tim O'Conner, *California Cap-and-Trade Program Frequently Asked Questions*, ENVTL. DEF. FUND (Jan. 2012), http://www.

climate change programs, California has one of the most efficient developed economies in the world.[166] Its success in creating this innovative program, which uses virtually the same mechanisms as Kyoto, demonstrates that while the collective action problem could not be overcome on the global scale, California overcame its internal collective action challenge and was able to act unilaterally at the state level.

Commentators have argued that the United States should use California's leadership to advance progressive policies on a national front and extend California's landmark economy-wide carbon cap-and-trade program to other states.[167] Authority for this action comes from the Clean Air Act[168] and, more specifically, from the holding of *Massachusetts v. EPA*,[169] in which the United States Supreme

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edf.org/sites/default/files/EDF-Cap-and-Trade-FAQ-January-2012.pdf; Gregory Freeman et al., *The AB 32 Challenge: Reducing California's Greenhouse Gas Emissions*, L.A. COUNTY ECON. DEV. CORP. (Jan. 2008), http://www.laedc.org/reports/TheAB32Challenge.pdf.

166. Freeman, *supra* note 165.

167. *See, e.g.*, Ann E. Carlson, *The President, Climate Change, and California*, 126 HARV. L. REV. F. 156, 156 (2013); Mary D. Nichols, *California's Climate Change Policies: Lessons for the Nation,* 2010 CARBON & CLIMATE L. REV. 154, 154-55 (2010).

168. Clean Air Act, 42 U.S.C.A. § 7601 *et seq.* (1990).

169. *See* Massachusetts v. E.P.A., 549 U.S. 497, 526, 528, 532 (2007). In light of scientific research connecting the increase of emissions to global warming, the state of Massachusetts (among others) petitioned the Environmental Protection Agency (EPA) to regulate gas emissions from cars in an effort to protect the state's interest in its coastal lands. *Id.* at 510. In an administrative decision, the EPA determined that it lacked authority under the Clean Air Act to regulate carbon dioxide and other GHGs for climate change purposes. *Id.* at 528. Massachusetts appealed the decision and was granted a writ of certiorari. *Id.* at 506. The Supreme Court held that the Clean Air Act requires the EPA to regulate greenhouse gases from vehicle emissions. *Id.* at 519. The Court made two important determinations: (1) states were found to have standing as quasi-sovereigns because of their interest in their costal lands and demonstrated injury of losing coastal property as the water rises; and (2) the scientific uncertainty connecting man-made carbon dioxide emissions to global warming was not a valid reason for the EPA to not regulate a known pollutant. *Id.* at 523-26, 534. The Supreme Court may expand these authorities when it reviews Chamber of Commerce of U.S. v. E.P.A., 642 F.3d 192, 196 (D.C. Cir. 2011) (questioning the EPA's authority under federal law regulating tailpipe emissions to also regulate carbon dioxide emissions from statutory sources like power plants).

Court held that greenhouse gases endanger public health and welfare.[170] A successful implementation on a national front, Carlson argues, would afford the United States the "moral authority to take a real leadership role on the international stage, both through the United Nations framework and in bilateral and multilateral negotiations with other large-emitting countries."[171]

The value of these interventions may be as fairly large-scale policy experimentations. While they might not be big enough to have a significant global impact directly, they may be large enough to show that action is possible in reasonably large, diverse communities without hindering development or bankrupting the region, such that other regions or states might in turn decide to take it up. They may also have value in providing a starting point for others that may want to observe and then follow suit, such that there might eventually be a critical mass large enough to have a global impact.

Based on the framework outlined in this Article, policy-makers may evaluate the likelihood of successful deployment of specific policies by using a scientific uncertainty/scale/collective action matrix. Table 2 illustrates how some of the proposals presented in this Article might be evaluated based on that matrix.

170. Carlson, *supra* note 167, at 157.

171. *Id.* at 156-57.

Policy for Evaluation	**Sensitivity to Scientific Uncertainty**	**Spatial Scale**	**Collective Action Problem**
Global insurance fund (contributions based on historic and current emissions or macroeconomic benchmark?)	Low sensitivity: Reliance on global modeling	Global scale implementation, local scale impact	Variable depending how contributions are defined
Unilateral intervention	Low sensitivity	Local to mid-scale impact	Low
Global repository of local and regional best practices	Low sensitivity	Global scale implementation, multi-scale impact	Low if low cost of implementation
Local prevention scheme	Higher sensitivity (but depends on perception)	Local scale	Low

Table 2: Evaluating Policies under a Scientific Uncertainty/Scale/Collective Action Matrix: Some Illustrations

CONCLUSION

In an ideal world, a successful policy in the climate change realm is one that has a low collective problem, is implemented on a global scale with a global reach, and has a low sensitivity to scientific uncertainty. As demonstrated by the literature survey and case studies above, there have been few, if any, policies that meet this ideal policy model. History shows that large-scale policies that incorporate science with a low sensitivity to uncertainty have been ineffective due to a collective action problem; whereas policy-makers are typically more able to overcome coordination problems at the local level, despite the much higher degree of uncertainty in the science. A recent high-profile U.S. government report on climate change in the United States recognizes that policy-making for adaptation to and mitigation of extreme events takes place at the state, tribal, and local government level. It also notes the need to help policy-makers understand state-of-the-art scientific information on climate change trends.[172] Nonetheless, the report's continued expectation that decision-making can be crafted in reaction to ever-improving science models[173] misses the fundamental point of the increased uncertainty at granular scales, combined with the low chance that such uncertainty will reduce in the near future.

Our goal, then, is to encourage policy-makers to approach extreme weather policy while considering how the factors of scientific uncertainty, spatial scale, and the problem of collective action work together. The hope is that policy attempts (both successes and failures) become part of a repository for future policy-makers so that mistakes are not repeated and the collective action problem may eventually become obsolete.

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172. *U.S. Third National Climate Assessment*, *supra* note 1, at 634 ("There is also a need for 'science translators' who can help decision-makers efficiently access and properly use data and tools that would be helpful in making more informed decisions in the context of climate change.").

173. *Id.* at 635 ("Probabilistic forecasts or other information regarding consequential climate extremes/events have the potential to be very useful for decision-makers, if used with improving information on the consequences of climate change and appropriate decision supporting tools.").