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CLIMATE CHANGE INSURANCE AND DISASTERS: IS THE SHENZHEN SOCIAL INSURANCE PROGRAM A MODEL FOR ADAPTATION?

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Abstract: As one of the most disaster-prone nations, China is grappling with creating effective adaptation strategies. In an effort to pool risk, Chinese officials are introducing new climate change insurance products. This Article describes one pilot product introduced in the City of Shenzhen, a global megacity with a population of approximately fifteen million, and explores its strengths and weaknesses as a model for adaptation to climate change. This Article concludes with proposals for reducing risk within mega-cities and pooling risk among them.

INTRODUCTION

Funded insurance policies play an important financial buffer role for national economies allowing communities to rebound from natural disasters. For many countries, insurance claims have provided financing for 30–40% of the existing disaster losses.¹ These losses include both loss of human lives and property.² So-called “advanced economies” fare better than “emerging economies” with 53% of the losses covered as compared to 6.6%

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¹ Coco Liu, *Millions of China's Farmers Now Buy Climate-Change Insurance*, CLIMATE WIRE, SCI. AM. (Apr. 22, 2014), <http://www.scientificamerican.com/article/millions-of-chinas-farmers-now-buy-climate-change-insurance/> [https://perma.cc/K263-VS5D].

² *Three Months After the Indian Ocean Earthquake-Tsunami Report*, WORLD HEALTH ORG., http://www.who.int/hac/crises/international/asia_tsunami/3months/report/en/ [https://perma.cc/N8C7-57NX]. The 2004 tsunami that impacted Indonesia, Thailand, and other Southeast Asian states killed approximately 280,000 people and injured many more. *Id.* The 2010 floods in Pakistan impacted twenty million people and caused approximately \$10 billion in damages. K. ALAN KRONSTADT ET AL., CONG. RESEARCH SERV., FLOODING IN PAKISTAN: OVERVIEW AND ISSUES FOR CONGRESS 1 (2010), <https://www.fas.org/sgp/crs/row/R41424.pdf> [https://perma.cc/9N5Q-YNSR].

of losses, respectively.³ Historically, most of the claims for losses associated with national disasters have been concentrated in North America, but this has been changing with large recent insurance losses in Asia, Oceania, and Latin America.⁴ Even with these geographical shifts in losses, the insurance market in Asia remains almost inconsequential.⁵

Payments for natural disaster losses in the last few decades have been possible because companies, particularly reinsurance companies, have been able to spread disaster losses across time and across geographies.⁶ As the intensity and frequency of disasters are increasingly attributed in some part to climate change, insurance companies have taken a close look at the impact of climate change on their policies.⁷ Less work has been done in developing new insurance approaches designed to address the aftermath of climate-change related losses particularly for mega-cities.⁸ Instead, insur-

³ CHARTERED INS. INST., SOCIAL VALUE OF INSURANCE, CLIMATE CHANGE AND INSURANCE: NOT JUST COPING BUT HELPING . . . 2 (2015), http://www.cii.co.uk/media/6196029/svi-5_climate_change_june2015.pdf [https://perma.cc/JZL9-GWCJ].

⁴ Sebastian von Dahlen & Goetz von Peter, *Natural Catastrophes and Global Reinsurance—Exploring the Linkages*, BIS Q. REV., Dec. 2012, at 23, 25–26, <http://www.bis.org/publ/qtrpdf/rqt1212e.pdf> [https://perma.cc/Y8LY-5937].

⁵ See SIGMA, SWISS RE, NATURAL CATASTROPHES AND MAN-MADE DISASTERS IN 2014: CONVECTIVE AND WINTER STORMS GENERATE MOST LOSSES 7 tbl.3, 11–12 (2015), http://media.swissre.com/documents/sigma2_2015_en_final.pdf [https://perma.cc/62VS-3JXA]. In 2014, 60% of economic losses from natural disasters in North America were recoverable under insurance in contrast to 10% of similar economic losses in Asia. *Id.*

⁶ See, e.g., *International Locations*, MUNICH RE, <http://www.munichre.com/en/career/munich-re-as-an-employer/corporate-structure/locations/index.html> [https://perma.cc/7CLZ-FRP5] (noting that MunichRe has 5000 clients worldwide in North America, South America, Europe, Africa, Asia, and Australia).

⁷ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, MANAGING THE RISKS OF EXTREME EVENTS AND DISASTERS TO ADVANCE CLIMATE CHANGE ADAPTATION 9 (2012), http://ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf [https://perma.cc/DJK9-RF6Z] (noting medium confidence that the increase in heavy precipitation has been caused by anthropogenic climate change); see U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-07-285, CLIMATE CHANGE: FINANCIAL RISKS TO FEDERAL AND PRIVATE INSURERS IN COMING DECADES ARE POTENTIALLY SIGNIFICANT 5 (2007), <http://www.gao.gov/assets/260/257686.pdf> [https://perma.cc/NM5N-MA72]. See generally Evan Mills, *A Global Review of Insurance Industry Responses to Climate Change*, 34 GENEVA PAPERS 323, 359 (2009), <http://evanmills.lbl.gov/pubs/pdf/gpp200914a.pdf> [https://perma.cc/HSS2-EZLU] (discussing the response of insurance companies to global climate change).

⁸ See *Mongolia: Index Based Livestock Insurance Project*, WORLD BANK (Sept. 24, 2009), <http://www.worldbank.org/en/news/feature/2009/09/23/index-based-livestock-insurance-project> [https://perma.cc/468B-A7EQ]. Innovative index insurance programs have been designed for specific producers in the Global South to alleviate losses associated with climate shifts including excessive rainfall, lengthy draughts, and large temperature fluctuations. *Id.*; see, e.g., Press Release, African Risk Capacity, Drought Triggers ARC Insurance Payout in Sahel Ahead of Humanitarian Aid 1 (Jan. 22, 2015), http://www.africanriskcapacity.org/documents/350251/844579/PI_Press+Release+Sahel+Payouts+_EN_22012015_vFinal_CR.pdf [https://perma.cc/8KDL-LNRP] (demonstrating payouts from insurance companies to alleviate losses associated with climate shifts such as lengthy droughts).

ance companies have largely relied on existing products such as first-person health insurance or property insurance to cover losses from floods, fires, and heat waves.

The insurance industry is understandably worried about its exposure to the weather; for instance, scholars observe that the probability of an extreme meteorological event is rapidly changing.⁹ Climate scientists predict with a high level of confidence that human impacts on the quantity of greenhouse gases in the atmosphere have at least doubled the risk of severe heatwaves like the European heatwave of 2003 that resulted in the hottest summer since 1500 AD and several fatalities.¹⁰ Further, major tropical storms, both in the Atlantic and the Pacific region, have been increasing in duration and intensity by about fifty percent since the 1970s.¹¹

The insurance industry, particularly in the Global North, has reacted to these changes. In 2015, the Chartered Insurance Institute, a professional organization for the insurance industry, connected particular events to climate change triggers and announced \$3.2 trillion of losses that it attributed to climate change.¹² To evaluate the impacts of climate change on the insurance industry, a number of the larger reinsurers including Munich Re and Swiss Re are maintaining a “climate change event database.”¹³ Unfortunately for policyholders, adjusting some of the traditional premium-driven mechanisms to respond to climate change risks has led to the cancellation of some policies and to expansive increases in premiums for other policies.¹⁴

In 2014, Shenzhen, China began its large-scale experiment with a nationally funded city-wide model of disaster insurance created as part of a larger national strategy of socio-economic adaptation, which should interest more than simply Chinese citizens.¹⁵ By 2050, the United Nations predicts

⁹ Peter Hoeppe & Eugene N. Gurenko, *Scientific and Economic Rationales for Innovative Climate Insurance Solutions*, 6 CLIMATE POL’Y 621, 622 (2006).

¹⁰ See Peter A. Stott et al., *Human Contribution to the European Heatwave of 2003*, 432 NATURE 610, 610 (2004).

¹¹ See P.J. Webster et al., *Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment*, 309 SCI. 1844, 1846 (2005).

¹² CHARTERED INS. INST., *supra* note 3.

¹³ *Id.*

¹⁴ EVAN MILLS & EUGENE LECOMTE, CERES, FROM RISK TO OPPORTUNITY: HOW INSURERS CAN PROACTIVELY AND PROFITABLY MANAGE CLIMATE CHANGE 12 (2006), <http://www.ceres.org/resources/reports/how-insurers-can--manage-climate-change-2006> [<https://perma.cc/89FT-NDDP>] (describing examples where insurance companies decided not to renew homeowners’ policies).

¹⁵ Susan Munro & Amy Wang, *China Announces Policies to Accelerate Development of Chinese Insurance Industry*, STEPTOE & JOHNSON LLP (July 15, 2014), <http://www.steptoel.com/publications-9727.html> [<https://perma.cc/WCE6-WUH3>].

that eighty percent of the world's population will live in urban areas.¹⁶ In East Asia, the World Bank predicts that the urban population will double between 1994 and 2025.¹⁷ Cities are particularly vulnerable to climate change. As urbanization has increased rapidly in the last several decades leading to more individuals concentrated in urban areas, natural disaster impacts have become increasingly concentrated.¹⁸ For example, population density and a lack of construction regulations in Port au Prince, Haiti intensified the impacts of the 2010 earthquake.¹⁹ The same trend towards global urbanization is also increasingly exposing new urban lands to climate threats because at least some of the lands are reclaimed lands that are at or just above sea level.²⁰ For example, in the Netherlands the amount of urban area that may be flooded during an extreme weather event has increased six times in the twentieth century and is expected to continue to increase through this century.²¹ These impacts on cities will be costly; experts estimate that if Boston fails to invest in climate-adaptive efforts, the city will suffer \$57 billion of loss by 2100 with \$26 billion of those losses attributed to climate change.²² Megacities in Asia with a population of more than five million people are particularly vulnerable because 65% of these megacities are located in "low elevation coastal zone" regions.²³

This Article queries whether a model of municipal social insurance will offer an effective adaptive response to the increasing threat of climate

¹⁶ DEP'T OF ECON. & SOC. AFFAIRS, UNITED NATIONS, WORLD URBANIZATION PROSPECTS: THE 2011 REVISION 14 (2012), http://www.un.org/en/development/desa/population/publications/pdf/urbanization/WUP2011_Report.pdf [<https://perma.cc/54XG-XLQR>].

¹⁷ See ABHAS K. JHA & HENRIKE BRECHT, WORLD BANK, AN EYE ON EAST ASIA AND PACIFIC: BUILDING URBAN RESILIENCE IN EAST ASIA 2 (n.d.), http://siteresources.worldbank.org/INTEASTASIAPACIFIC/Resources/226262-1291126731435/EOEA_Abhas_Jha_April2011.pdf [<https://perma.cc/D5BK-KUSB>].

¹⁸ See DEP'T OF ECON. & SOC. AFFAIRS, UNITED NATIONS, *supra* note 16 (noting that 54% of the world's population currently lives in cities and projections indicate that 66% of the world's population will be living in cities by 2050).

¹⁹ See Kathleen A. Tobin, *Population Density and Housing in Port-au-Prince: Historical Construction of Vulnerability*, 39 J. URB. HIST. 1045, 1054 (2013) (noting that approximately 30% of Haiti's 9.8 million people lived in Port au Prince when the earthquake struck).

²⁰ David Fogarty, *Singapore Raises Sea Defences Against Tide of Climate Change*, REUTERS (Jan. 27, 2012), <http://www.reuters.com/article/uk-climate-singapore-idUSLNE80Q00J20120127> [<https://perma.cc/T3GT-EB2M>] (describing Singapore as a nation that has reclaimed land in order to expand its land area but is now faced with installing sea walls to prevent flooding from sea level rise).

²¹ Hans de Moel et al., *Development of Flood Exposure in the Netherlands During the 20th and 21st Century*, 21 GLOB. ENVTL. CHANGE 620, 624 (2011).

²² Alistair Hunt & Paul Watkiss, *Climate Change Impacts and Adaptation in Cities: A Review of the Literature*, 104 CLIMATIC CHANGE 13, 27 (2011).

²³ Gordon McGranahan et al., *The Rising Tide: Assessing the Risks of Climate Change and Human Settlements in Low Elevation Coastal Zones*, 19 ENV'T & URBANIZATION 17, 29 (2007).

change for urban centers. In this Article, adaptation is understood as referring to “the process of adjustment to actual or expected climate and its effects,” and in particular any action that “seeks to moderate harm or exploit beneficial opportunities.”²⁴ Insurance is commonly understood as part of a broader adaptation strategy.²⁵ It has also been embraced by the G-7 nations—Canada, France, Germany, Great Britain, Italy, Japan, and the United States—as part of an international development agenda.²⁶ Part I describes the social insurance pilot designed in Shenzhen, China.²⁷ Part II reflects on whether insurance and particularly municipal social insurance like the Shenzhen model can provide adequate adaptation to the threats of climate change.²⁸ Part III suggests that targeted subsidies for climate-proofing businesses and residences and global pooling of catastrophe risk among megacities will be necessary if insurance programs like the Shenzhen pilot are to be effective as an adaptation mechanism for climate change impacts.²⁹

I. CHINA’S DISASTER SOCIAL INSURANCE PILOT

In 2014, China experienced losses of sixty-nine billion yuan, approximately \$10 billion in U.S. dollars, due to natural disaster.³⁰ China hosts large numbers of factories, especially in the Pearl River Delta Economic Zone region, where about 40% of the western side of the delta is two meters or less above sea level.³¹ Presently only about 10% of the total economic

²⁴ Christopher B. Field et al., Intergovernmental Panel on Climate Change, *Summary for Policymakers*, in CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY 1, 5 (C.B. Field et al. eds., 2014), https://ipcc-wg2.gov/AR5/images/uploads/WG2AR5_SPM_FINAL.pdf [<https://perma.cc/2TPR-NXS6>].

²⁵ Ian R. Noble et al., *Adaptation Needs and Options*, in *id.* at 845.

²⁶ See Press Release, White House Office of the Press Sec’y, G-7 Leaders’ Declaration (June 8, 2015), <https://www.whitehouse.gov/the-press-office/2015/06/08/g-7-leaders-declaration> [<https://perma.cc/K37B-TS8Z>] (calling for the G-7 States “to increase by up to 400 million the number of people in the most vulnerable developing countries who have access to direct or indirect insurance coverage against the negative impact of climate change related hazards by 2020 and support the development of early warning systems in the most vulnerable countries” and to “learn from and build on already existing risk insurance facilities such as the African Risk Capacity, the Caribbean Catastrophe Risk Insurance Facility and other efforts to develop insurance solutions and markets in vulnerable regions, including in small islands developing states, Africa, Asia and Pacific, Latin America and the Caribbean”).

²⁷ See *infra* notes 30–52 and accompanying text.

²⁸ See *infra* notes 53–101 and accompanying text.

²⁹ See *infra* notes 102–141 and accompanying text.

³⁰ See Luo Bin, *China Confirms Plan for Setting Disaster Insurance System*, CRIENGLISH.COM (Oct. 17, 2014), <http://english.cri.cn/12394/2014/10/17/3746s848346.htm> [<https://perma.cc/8KQ3-6ZTE>].

³¹ KAI-UWE SCHANZ & SHAUN WANG, GENEVA ASS’N, INSURING FLOOD RISKS IN ASIA’S HIGH-GROWTH MARKETS: A GENEVA ASSOCIATION RESEARCH REPORT 35 (2015), <http://www.>

losses in this region are insured against a hundred-year storm surge.³² Under current sea level predictions, unless there are substantial reductions in the production of greenhouse gases or an increase in coastal buffers, forty-one to sixty-three million people across China will be exposed to increased levels of flood exposure.³³ Insurers predict that even if current levels of flood probability can be maintained, hundred-year asset exposure losses in cities such as Guangzhou, with a population of 8.5 million people, could increase from around \$39 billion to \$500 billion by 2050.³⁴

In addition to Guangzhou, China is home to between three and five of the twenty global coastal cities most exposed to future flood losses, depending on whether one takes into account the proportion of Gross Domestic Product (GDP) lost to flooding.³⁵ China's national government understands its exposure to large-scale national disasters and has been strategically investing national resources to address the spreading of risk. Since the 1980s, the Chinese government has heavily subsidized crop catastrophe insurance and for the past decade the China Insurance Regulatory Commission ("CIRC") has been very supportive of rolling out more pilot programs to deliver general catastrophe insurance.³⁶ The CIRC, along with the primary government ministries, is a key player in the disaster management system within China.³⁷

The Disaster Insurance Pilot in Shenzhen, also referred to in literature as the Catastrophe Insurance Framework, is the first experiment by the Government of China to spread risks associated with climate change events through catastrophe insurance at the municipal level.³⁸ One of the global

iisonline.org/files/TC/PDF/ga2015-insuring-flood-risk-in-asias-high-growth-markets.pdf [https://perma.cc/KM2F-C4DL].

³² *Id.* at 9.

³³ *Id.*

³⁴ *See id.* at 9, 11. This prediction of a substantial increase in financial losses can be attributed in part to the large increases in Global Gross Domestic Product (GDP), especially in "emerging Asia," where the GDP has increased from 6% in 2000 to 22% in 2013. *Id.*

³⁵ *See* Stephane Hallegatte et al., *Future Flood Losses in Major Coastal Cities*, 3 NATURE CLIMATE CHANGE 802, 803 (2013), <http://www.nature.com/nclimate/journal/v3/n9/pdf/nclimate1979.pdf> [https://perma.cc/GM8H-A8FV]. Based on measuring just the economic average annual losses, China is home to the first (Guangzhou), ninth (Shenzhen), and twelfth (Tianjin) most risk exposed cities in the world, based on the level of risk in relation to percentage of GDP. *Id.* Based on measuring the level of economic average annual losses in relation to the percentage of GDP that may be lost, China is home to the first (Guangzhou), sixth (Zhanjiang), tenth (Shenzhen), eighteenth (Tianjin), and twentieth (Xiamen) most risk exposed cities in the world. *Id.*

³⁶ *See* Meixian Song & Yiqing Yang, *Introduction to Chinese Insurance Law*, in INSURANCE LAW IN CHINA 9 (Johanna Hjalmarsson & Dingjing Huang eds., 2015).

³⁷ *See* YI KANG, DISASTER MANAGEMENT IN CHINA IN A CHANGING ERA 41 (2015).

³⁸ *China: Shenzhen Launches Its First Disaster Insurance Pilot Scheme*, ASIA INS. REV. (July 17, 2014), <http://www.asiainsurancereview.com/News/View-NewsLetter-Article/id/30681/Type/>

reinsurer leaders, Swiss Re, is offering technical assistance and reinsurance for the program.³⁹ Shenzhen was selected for the pilot because it has major exposure to a variety of potential disaster threats, a large number of valuable assets, and is experimenting with a carbon market to reduce greenhouse gas emissions.⁴⁰ With approximately fifteen million residents, the mega-city has a large amount of infrastructure, including an airport and railways, that are vulnerable to flooding, a phenomenon that has become increasingly familiar to Shenzhen residents in the past few years.⁴¹ The hope is that the pilot can be scaled up to address similar threats in the numerous other Chinese coastal cities where assets are exposed.⁴²

This catastrophe insurance framework includes three different interacting tiers of insurance. The first tier is the government catastrophe assistance insurance, which is bought by the Shenzhen municipal government to supply basic assistance to all residents.⁴³ The government of the City of Shenzhen is purchasing its catastrophe insurance products from the People's Insurance Company of China's ("PICC") Shenzhen branch whose coverage is underwritten by Swiss Re, China Re, and Taiping Re.⁴⁴ This insurance functions as indemnity insurance: the insurance company will pay for actual

eDaily/China-Shenzhen-launches-its-first-disaster-insurance-pilot-scheme [https://perma.cc/W8FB-TFC6].

³⁹ *Swiss Re Works with Government Bodies in Mitigating Natural Catastrophe Risks in China*, SWISS RE (Aug. 13, 2014), http://www.swissre.com/china/Swiss_Re_works_with_government_bodies_in_mitigating_natural_catastrophe_risks_in_China.html [https://perma.cc/88RV-NLHR].

⁴⁰ Jiajun Wang, *Research on Legislation Pattern of Catastrophe Insurance in Major City of China—Based on Study on Pilot Work of Catastrophe Insurance in Shenzhen*, 29 J. POSTGRADUATE ZHONGNAN U. ECON. & L. 81, 81–87 (2013) (identifying between 2000 and 2007 the occurrence of thirty rainstorms, nine typhoons, ten heatwaves, four hail storms, five drought events, and eight freeze events).

⁴¹ Jasmin Sasin, *Shenzhen Ranks Fifth in the World in Terms of Population Density*, SHENZHEN STANDARD (Mar. 25, 2014), <http://www.shenzhen-standard.com/2014/03/25/shenzhen-ranks-fifth-in-the-world-in-terms-of-population-density/> [https://perma.cc/F2VH-ZZZZ]; see David Biello, *Climate Change Will Be Solved in Cities—Or Not at All*, SCI. AM. (Sept. 23, 2014) (noting Shenzhen's population size). See generally He Huifeng & Clifford Lo, *Shenzhen Residents Slam Authorities After City Paralyzed by Floods*, S. CHINA MORNING POST (May 13, 2014), <http://www.scmp.com/news/china/article/1510882/shenzhen-residents-slam-authorities-after-city-paralysed-floods> [https://perma.cc/UNN5-DL4B] (observing that Shenzhen city has not been accountable on spending to improve drainage and flood control).

⁴² R.J. Nicholls et al., *Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes* 27 (Env't Directorate, Working Paper No. 1, 2007), [http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP\(2007\)1&doclanguage=en](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP(2007)1&doclanguage=en) [https://perma.cc/8N8J-YVN6].

⁴³ PICC PROP'Y & CASUALTY CO., LTD., CATASTROPHE INSURANCE FRAMEWORK OF SHENZHEN CITY 4, 7 (2015).

⁴⁴ *China Re, Swiss Re, and Taiping Re Underwrite the Shenzhen Catastrophe Reinsurance Policies*, SINOINS.COM (July 6, 2014), http://xw.sinoins.com/2014-07/16/content_121575.htm [https://perma.cc/U7ND-6JBE] (underwriting from multiple reinsurance agencies).

medical costs and pension costs due to victims' injuries or deaths caused by the disasters. Payment for a single disaster event is capped at two billion yuan with maximum individual claims of 100,000 yuan, approximately \$15,710 in U.S. dollars.⁴⁵ The pilot program clearly does not contemplate a claim being made by a large number of citizens for any single event; because coverage for a single disaster event is capped at two billion yuan, the program will be able to deliver maximum individual relief to 25,000 individuals in the event of a disaster.⁴⁶

The second tier is a catastrophe fund managed by the City of Shenzhen.⁴⁷ Capital sources of the catastrophe fund include government appropriation, social donation, and investment earnings.⁴⁸ Where catastrophe losses exceed the cap of 2.5 billion yuan available in the first tier of insurance, the catastrophe fund should provide extra coverage.⁴⁹ In addition, the City of Shenzhen intends to issue catastrophe insurance linked securities, such as catastrophe bonds, and thus transfer catastrophe risk to capital markets.⁵⁰ The government-funded policy covering the first and second tiers of the insurance framework is limited in scope and covers only fifteen events including heavy winds, rainstorms, lightning strikes, floods, waterlogging, tornado, typhoons, tsunamis, hail, landslides, mudslides, cliff slides, land subsidence, severe thunderstorms, and earthquakes of more than 4.5 magnitude.⁵¹ The final tier is private catastrophe insurance to cover property losses.⁵² Because domestic property insurance is a very new product in China, this tier of insurance is still being developed.

II. IS THE SHENZHEN MODEL OF SOCIAL INSURANCE A MODEL FOR CLIMATE ADAPTATION FOR MEGACITIES?

The introduction of social insurance in the context of climate change risk management is not a new innovation. For example, the World Bank's Global Index Insurance Facility has been supporting the development of index-based disaster insurance for farmers, pastoralists, and micro-

⁴⁵ *Catastrophe Insurance Framework of Shenzhen City*, *supra* note 43; Martin Li & Yin Ran, *SZ Launches 1st Disaster Insurance*, SHENZHEN DAILY (July 10, 2014), http://szdaily.sznews.com/html/2014-07/10/content_2936724.htm [<https://perma.cc/NHB6-M6HB>].

⁴⁶ *See Catastrophe Insurance Framework of Shenzhen City*, *supra* note 43.

⁴⁷ *Id.*; see Li & Ran, *supra* note 45 (describing a thirty-million-yuan catastrophe fund).

⁴⁸ *See Li & Ran*, *supra* note 45.

⁴⁹ *Catastrophe Insurance Framework of Shenzhen City*, *supra* note 43.

⁵⁰ Yisha Hou, *Promoting the Construction of Shenzhen Catastrophe Insurance System*, 25 DISASTER REDUCTION IN CHINA 42–45 (2015).

⁵¹ *Id.*

⁵² *Catastrophe Insurance Framework of Shenzhen City*, *supra* note 43.

entrepreneurs for the last five years.⁵³ What is new about the nationally funded city-wide model of disaster insurance in Shenzhen is that it is an insurance product that has been developed for urban recovery.⁵⁴ Although the Shenzhen model of social insurance is only a pilot at this point, could this insurance program represent a new viable model of adaptation to climate change not just for municipalities in China but also for other states? The program has only been in effect for about a year and so there is little public data assessing the pilot. Some general observations based on the structure of the insurance pilot may be useful in thinking about the role of insurance in climate adaptation for cities where there is likely to be large aggregation of individual losses in close proximity.

A. Positive Values of the Shenzhen Social Insurance Model for Climate Change Adaptation

Compared to the absence of any other available insurance, the Shenzhen model offers a number of distinct advantages.⁵⁵ First, the model provides timely relief for citizens and operates as a safety net particularly for the poorest residents who do not have disposable income to cover the costs associated with bodily injuries arising from disasters.⁵⁶ Many of these poor individuals may be located in the most disaster-prone areas of the cities and are also the most likely to be gravely injured in a disaster.⁵⁷ There is evidence that micro-insurance products providing even small payments to parties experiencing losses have been important in low-income communities to help them financially rebound.⁵⁸ Even small sums of money, such as that offered by the Shenzhen program, that are delivered in a timely fashion may make a difference in covering basic medical costs that would allow individuals to return to the workforce more rapidly. The substantial challenge for the Shenzhen program operating in a dense urban environment will be to

⁵³ See *Global Index Insurance Facility*, INT'L FIN. CORP., http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/industries/financial+markets/retail+finance/insurance/global+index+insurance+facility [<https://perma.cc/TU7T-XRMW>].

⁵⁴ See *China: Shenzhen Launches Its First Disaster Insurance Pilot Scheme*, *supra* note 38.

⁵⁵ See *infra* notes 57–74 and accompanying text.

⁵⁶ See generally Li & Ran, *supra* note 45 (explaining the program, funded by the government, will cover costs relating to medical expenses, disabilities, and death caused by the disaster).

⁵⁷ See *id.*; see also Somik V. Lall & Uwe Deichmann, *Density and Disasters: Economics of Urban Hazard Risk* 19 (World Bank, Working Paper No. 5161, 2009), <https://openknowledge.worldbank.org/bitstream/handle/10986/4348/WPSS161.pdf?sequence=1> (observing that in Bogota, Columbia, the poorest individuals live in some of the most disaster vulnerable areas of the city because these areas offer low rent).

⁵⁸ See Stefan Hochrainer et al., *Micro-insurance Against Drought Risk in a Changing Climate: Assessing Demand and Supply Considerations*, 2 INT'L J. CLIMATE CHANGE STRATEGIES & MGMT. 148, 149 (2008).

determine the optimal means for delivering payments if critical infrastructure, such as postal services, were to be disrupted by an earthquake or flood.

Second, the existence of the insurance gives a strong incentive for Shenzhen to issue early warnings and to prioritize residents' safety by creating and enforcing disaster-oriented municipal codes. Shenzhen is not a passive player in the insurance scheme but has invested several million yuan into issuing insurance.⁵⁹ These sums are annually paid in order to build up financial capital in the fund for disasters that are unavoidable "perfect storms." It is not in the city's best interest to have its invested sums depleted by events where the population could have been warned to evacuate or where the population could have been protected by code enforcement efforts. To reduce risk, the Shenzhen model offers risk-based premiums; for instance, the model's thirty-six million yuan annual premium is decided based on catastrophe model analysis, actuarial evaluation, and international reinsurance prices.⁶⁰ Risk-based premiums enable insurers to provide a discount to the government for adopting cost-effective mitigation measures.⁶¹ It provides that if the annual loss ratio—actual payment amount/total premium—is less than 10%, then the premium for the following year will be given a 10% discount; if the loss ratio is less than 10% in two consecutive years, the third year's premium will have a 20% discount; if the loss ratio is less than 10% in three consecutive years, the fourth year's premium will have a 30% discount.⁶² Ultimately, the local municipality, in light of both the interest of public safety and its own financial interests, has the incentive to prioritize the development of a risk-aware culture.

Offering a third advantage, the Shenzhen model reflects an important departure from current national practices of managing disasters by relying on centralized management. The Chinese mechanism for adapting to climate change risks is known as the "Whole-Nation System" ("Juguo tizhi") and is generally activated to deliver disaster emergency relief; when triggered, the government will deploy and allocate key resources from across the nation to provide emergency relief.⁶³ While effective in delivering emergency relief in the short-run, it is not sustainable in the long-term because it reduces community incentives to invest in protection and mitigation measures, burdens public budgets, and contributes to perverse incentives for

⁵⁹ See *id.*

⁶⁰ See *id.*

⁶¹ See HOWARD KUNREUTHER, CATASTROPHE INSURANCE CHALLENGES FOR THE U.S. AND ASIA 10–11 (2007) [<https://perma.cc/36Z6-28UX>] (original hyperlink no longer active).

⁶² *Id.*

⁶³ Qihao He, *Climate Change, Catastrophe Risk and Government Responsibilities* 4 (Aug. 4, 2015) (unpublished paper) (on file with author).

rent-seeking and corruption.⁶⁴ The Shenzhen model offers a broader diversification of risks by involving both public and private interests, which is important for ensuring that there are financial resources available to provide payments in the case of losses.⁶⁵

Another advantage of the Shenzhen model is that it builds on expertise from the insurance industry in providing loss prevention services. Historically, insurers have worked in tandem with experts, insureds, and other stakeholders to identify technical and economic parameters associated with loss prevention and to develop new insurance products for future loss prevention.⁶⁶ Under the Shenzhen model, knowledge from the insurance industry's research will be shared with the municipal government when the catastrophe insurers submit an annual report to the government on disaster risk management.⁶⁷ The Shenzhen model is structured to support additional investments in risk-related research. Five percent of the premium will be used to organize disaster research, disaster prevention, disaster emergency relief drills, and disaster emergency advertising.⁶⁸

A fifth advantage of social insurance is that its products potentially allow for the spreading of risk across a large population because social insurance products can be designed to be inclusive. Insurance depends on the "law of large numbers."⁶⁹ Unlike other insurance schemes, there is no need to opt-in to the municipal policy or the catastrophe fund.⁷⁰ The United States has in recent years faced challenges with its National Flood Insurance Program because even though the program is mandated for homes that have a federal mortgage within areas where hundred-year catastrophic floods are

⁶⁴ Qihao He, *Climate Change, Catastrophe Risk and Government Stimulation of Insurance Market—A Study of Transitional China*, 17 INT'L FIN. REV. (forthcoming 2016).

⁶⁵ See Howard Kunreuther & Mark Pauly, *Rules Rather than Discretion: Lessons from Hurricane Katrina*, 33 J. RISK UNCERTAINTY 101, 109–10 (2006); Saul Levmore & Kyle D. Logue, *Insuring Against Terrorism—and Crime*, 102 MICH. L. REV. 268, 277 (2003) (discussing the effect of the federal government providing reinsurance for property losses attributable to terrorism); Liu Minxia, *Shenzhen Pilots Disaster Insurance Program*, SHENZHEN DAILY (Jan. 2, 2014), http://www.szdaily.com/content/2014-01/02/content_8954764.htm [<https://perma.cc/G9FF-EQXX>] (describing investments by the city government for basic bodily coverage and opportunities for individual residents to purchase insurance policies with larger coverage).

⁶⁶ See Andrea Wells, *Tomorrow's Insurance Products Are Being Developed Today*, INS. J. (Dec. 19, 2005), <http://www.insurancejournal.com/magazines/features/2005/12/19/63975.htm> [<https://perma.cc/NX9G-UHCR>] (describing how insurance companies work with insured parties to understand "emerging" needs such as terrorism insurance and catastrophe insurance).

⁶⁷ *Catastrophe Insurance Framework of Shenzhen City*, *supra* note 43.

⁶⁸ *Id.*

⁶⁹ Richard Zeckhauser, *The Concise Encyclopedia of Economics: Insurance*, LIBRARY OF ECON. & LIBERTY (2008), <http://www.econlib.org/library/Enc/Insurance.html> [<https://perma.cc/D7DM-YRQZ>].

⁷⁰ *Id.*

predicted, only about forty-nine percent of homes within these flood zones actually have obtained flood insurance.⁷¹ Voluntary insurance policies would presumably fare even worse.

Finally, the Shenzhen social insurance pilot offers a degree of predictability about what a population might expect from its government in terms of an economic response. The Dutch Government has established an *ex post facto* compensation scheme, but there is apparently limited transparency regarding what events will be covered and how much compensation will be available.⁷² By knowing what will be covered under the social insurance components of the Shenzhen insurance, citizens can respond and acquire additional coverage. For example, the Shenzhen model encourages private commercial insurance to cover losses that exceed coverage under the social insurance components of the model.⁷³ Some private insurance products are currently being sold through private firms to Shenzhen residents.⁷⁴

B. Limitations of Shenzhen Social Insurance as a Model for Climate Change Adaptation

In addition to these potential benefits of diversification of risk across a large population and predictable and hopefully timely payments to some of the most vulnerable individuals in society, the Shenzhen model faces certain challenges as an adaptation strategy designed to enhance social resilience. Although the Shenzhen model seems promising in terms of providing the most basic of coverage for Shenzhen residents, there are a number of issues with applying the pilot as the model for future insurance schemes designed to enhance climate change adaptation. The primary concern with the current social insurance portion of the pilot is that the capitalization of the insurance will not be sufficient to cover the actual bodily damage or losses from a major disaster event or the property losses or business interruption losses that are necessary for securing long-term social resilience within a community. The coverage under the municipal policy is quite limited with a cap of 100,000 yuan for individual claim payments, and payments are only available for bodily damage and death.⁷⁵ According to an empirical research study conducted in 2013 in Shenzhen, more than seventy percent of the residents

⁷¹ LLOYD DIXON ET AL., RAND, THE NATIONAL FLOOD INSURANCE PROGRAM'S MARKET PENETRATION RATE: ESTIMATES AND POLICY IMPLICATIONS 8 (2006).

⁷² See W.J. WOUTER BOTZEN, MANAGING EXTREME CLIMATE CHANGE THROUGH INSURANCE 378 (2013).

⁷³ See Li & Ran, *supra* note 45.

⁷⁴ See Hou, *supra* note 50.

⁷⁵ See Li & Ran, *supra* note 45.

hoped that the coverage could be extended to 500,000 yuan for individual claim payments.⁷⁶

The Chinese government expects that property insurance will be offered by a private insurance market, but non-life insurance products such as property insurance have been notably absent from Asian markets, in part because of high residual risks that arise due to an under-enforcement of building codes and land-use planning.⁷⁷ Loss of business-related property or the lack of predictability of operating a business after a disaster may lead firms to either relocate or cease operations. These are real possibilities because very few small or medium sized businesses have planned for the financial implications of post-disaster recovery.⁷⁸ For example, in Thailand, the 2011 floods led to the closure of over 550,000 small and medium sized businesses and the loss of 2.3 million jobs.⁷⁹ The loss of firms, particularly those who are large employers, could lead to an outmigration from one community to others that are perceived as physically safer for investment.⁸⁰ With outmigration, communities may opt not to rebuild assets but instead abandon factories and terminate jobs.⁸¹

Offering some form of property coverage as part of social insurance will not be as straightforward as offering coverage for bodily injury. The challenge will be to assess appropriate risk-based premiums for those types of extreme risks that would drive displacement from a community. An additional challenge for designing any insurance product will be narrowing the gap between insured losses and actual losses. Even though catastrophe models in the face of incidents driven by climate change are evolving, natural disasters are still relatively infrequent, so modeling for risk-based premiums reflects a substantial amount of uncertainty.⁸² Presumably, groups or individuals in particularly risky physical situations could be mandated to

⁷⁶ Wang, *supra* note 40.

⁷⁷ S.V.R.K. Prabhakar et al., *Current State of Risk Insurance in the Asia-Pacific Region, Promoting Risk Insurance in the Asia-Pacific Region*, in CLIMATE CHANGE ADAPTATION IN PRACTICE: FROM STRATEGY DEVELOPMENT TO IMPLEMENTATION 303, 305 (P. Schmidt-Thome & J. Klein eds., 2013).

⁷⁸ *Preparing SMEs for Disasters*, ASIA-PAC. ECON. COOP. (Aug. 28, 2015), http://www.apccsmc.org/news_in.aspx?siteid=&ver=&usid=&mnuid=1958&modid=234&mode=&nid=468&noframe [<https://perma.cc/2RR6-NADD>] (noting that among businesses surveyed in seventeen Asian Pacific countries, eighty-three percent of the small and medium sized enterprises (“SMEs”) did not participate in business continuity planning that might help them to recover after a disaster).

⁷⁹ *Id.*

⁸⁰ *See id.* (detailing the concerns surrounding SMEs suffering harm from natural disasters).

⁸¹ *See id.*

⁸² Carolyn Kousky & Roger Cooke, *Explaining the Failure to Insure Catastrophic Risks*, 37 GENEVA PAPERS 206, 221 (2012), http://www.rff.org/files/sharepoint/Documents/Events/Workshops%20and%20Conferences/Climate%20Change%20and%20Extreme%20Events/ProjectOutput/Explaining_the_Failure.pdf [<https://perma.cc/K89V-XP4K>].

carry some level of property or business interruption insurance. Mandatory coverage might be linked to ordinary financial transactions for a business. For example, in the United States, all federally regulated or federally insured mortgage holders who own property in a high-risk area—where there is a one in four chance of flooding in thirty years—must have a flood insurance policy.⁸³ This form of “bundled” insurance contributes to a broader adoption of insurance than would be seen with a voluntary program.⁸⁴

Premiums on any business or property insurance must be kept affordable for a sufficient number of parties in an area to be impacted. Until there are clear profit streams for private providers, the government will likely be the primary funder for insurance. For example, in the United States, where premiums associated with natural disaster losses have become unaffordable for many individuals, many states have established state-run natural disaster insurance arrangements.⁸⁵

The second concern with the current pilot is that the government catastrophe assistance insurance may inadvertently compete with the private insurance market in the coverage areas financed by the government. Because the Shenzhen municipal government will buy insurance for the residents, there is no need for the residents to pay premiums to opt-in to a voluntary insurance scheme.⁸⁶ This arrangement gives the residents incentives not to purchase insurance but instead to rely on the government. Curiously, the government support of this program appears to run counter to residents’ desires. According to an empirical research study conducted in 2013, only 4% of the residents hope that the government would pay premiums for them; 60% of them would prefer to purchase government-subsidized private catastrophe insurance.⁸⁷ These numbers may reflect a lack of trust that government agencies will choose adequate insurance products to cover its citizens.

A third concern with the current pilot is that it lacks legislative implementation at the municipal level and is administered through a more *ad hoc* approach. The city of Shenzhen has not enacted catastrophe insurance regu-

⁸³ *When Insurance Is Required*, FLOODSMART.GOV, https://www.floodsmart.gov/floodsmart/pages/about/when_insurance_is_required.jsp [<https://perma.cc/GLN2-XAWQ>].

⁸⁴ See SCHANZ & WANG, *supra* note 31, at 45 (noting that “bundled” insurance, which is mandatory in France and parts of the United States, can increase moral hazard by reducing incentives to avoid risk).

⁸⁵ For example, the Citizens Property Insurance Corporation was created by the Florida Legislature as a primary insurer for the state. *About Us*, CITIZENS PROP. INS. CORP., <https://www.citizensfla.com/web/public/who-we-are> [<https://perma.cc/T2AR-VG76>].

⁸⁶ See Li & Ran, *supra* note 45.

⁸⁷ See SCHANZ & WANG, *supra* note 31.

lations or any other corresponding implementing legal framework.⁸⁸ The Shenzhen municipal government may cease to buy catastrophe insurance policies without any penalty. Without a specific legislative framework in place to ensure accountability for Shenzhen citizens, the long-term prospect of this pilot is uncertain.

A fourth concern related to using insurance as a tool for climate adaptation is that the Shenzhen social insurance addresses only a select subset of climate change impacts. While historically the coastal city of Shenzhen has been faced with flood events, it is also possible that heat waves or outbreaks of infectious disease attributed to climate change events could result in city-wide impacts.⁸⁹ The current policy seems to be restricted to a certain smaller set of events.⁹⁰ While it may make sense to restrict financial exposure of the city to additional catastrophic risks, the limited number of events covered by the insurance constrains the effectiveness of the Shenzhen social insurance as an adaptation tool for climate change because the city is likely to focus its risk reduction efforts primarily on those climate-related risks covered by the insurance product (such as floods), and not on other climate related risks (such as heat waves).⁹¹

A fifth concern is that the Shenzhen model may create a situation of moral hazard by causing some parties to continue to undertake risky behaviors—such as putting workers in dangerous proximity to flood situations or building in flood-prone areas—because compensation should be available through the insurance scheme. In theory, if the insurance pool covers a sufficient amount of actual losses and the claim process is not too onerous, then there may be little social pressure to change “business as usual” practices.⁹² Insurance that pays economic compensation without the promise of effecting change would fail to function as an effective social adaptation mechanism. The issue of a society-wide moral hazard might be productively addressed by introducing some form of individual deductible that might include assigning ineligibility for a benefit if an insured party who is attempting to collect a claim fails to demonstrate some negotiated level of

⁸⁸ Xing Shi, *Inspirations of Shenzhen Catastrophe Insurance Pilot*, REUTERS INS. (Oct. 11, 2014), <http://insurance.hexun.com/2014-10-11/169210867.html> [<https://perma.cc/T2B9-GX48>].

⁸⁹ See Harrison Jacobs, *The 10 Cities Most at Risk of Being Hit by Natural Disasters*, BUS. INSIDER (Mar. 28, 2014), <http://www.businessinsider.com.au/cities-most-at-risk-of-natural-disasters-2014-3#3-pearl-river-delta-china-8>.

⁹⁰ See Li & Ran, *supra* note 45 (discussing the fifteen kinds of disasters that Shenzhen’s catastrophe based insurance pilot program covers).

⁹¹ See *id.*

⁹² See S.V.R.K. PRABHAKAR ET AL., INST. FOR GLOB. ENVTL. STRATEGIES, EFFECTIVENESS OF INSURANCE FOR DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION: CHALLENGES AND OPPORTUNITIES 4, 7 (2015).

risk reduction for a property or an activity. A blend of private responsibility with public responsibility may provide the necessary financial buffer that allows the public to cost-effectively underwrite a general insurance product like the Shenzhen insurance.

A final concern about applying the Shenzhen model as a climate change measure is that the success of the model depends on the fiscal capability of the local government. Shenzhen is a relatively affluent municipality and it may be difficult to extend the insurance model to other cities that lack the public finance resources to start up a similar insurance program.

C. Urban Social Insurance as Successful Climate Change Adaptation?

As individual citizens across the globe are experiencing climate change in a variety of forms ranging from temperatures that are too hot to temperatures that are too cold, the question is whether social insurance like the Shenzhen pilot can be considered successful climate change adaptation. In 2013, climate change researcher Neil Adger and his research team offered several potential criteria for measuring the success of adaptation, including effectiveness, efficiency, equity, and legitimacy.⁹³ The Shenzhen pilot can be measured by these four criteria.

Effectiveness can be measured by determining whether a given program achieves its objectives, including reducing impacts, exposures, and risk while promoting community security.⁹⁴ The existing Shenzhen insurance pilot is tailored to improve immediate financial security for individuals in the aftermath of a disaster, but there is no indication that, as designed, it will reduce long-term community exposure to repeat hazards such as flooding. Until the insurance payouts are linked explicitly to *ex ante* risk reduction measures, any city offering social disaster insurance will be simply handling *ex post* impacts.⁹⁵ On the adaptation criteria of effectiveness, the Shenzhen model appears to function largely as a short-term recovery tool rather than a mechanism to reduce overall community exposure.

The second criteria of adaptation, economic efficiency, can be evaluated on the basis of the distribution of costs and benefits.⁹⁶ On this measure of economic efficiency, the Shenzhen insurance is successful because it disburses a pool of limited public funds to private individuals who might, without the insurance, possibly require even more extensive public assis-

⁹³ See W. Neil Adger et al., *Successful Adaptation to Climate Change Across Scales*, 15 GLOB. ENVTL. CHANGE 77, 85 (2005) (noting that these criteria are not equally weighted by communities or over time).

⁹⁴ See *id.*

⁹⁵ See PRABHAKAR ET AL., *supra* note 92, at 7.

⁹⁶ See Adger et al., *supra* note 93, at 85.

tance from national or international actors. Economic efficiency is promoted in the social insurance components of the Shenzhen model through caps and maximum payments.⁹⁷

Regarding the third criteria, equity of outcome, the success of an adaptation can be measured by who wins, who loses, and who gets to make the decisions regarding the adaptation.⁹⁸ Whether the Shenzhen model insurance operates equitably remains to be seen, as it depends upon how the system responds in distributing payments after a disaster. There may be some groups who should receive payments for the injuries that they have incurred, such as the elderly and disabled, but may not promptly receive these payments due to existing social marginalization. In this way, disaster events tend to reinforce pre-existing power imbalances.⁹⁹

Finally, the success of an adaptation will depend on whether it is deemed a legitimate intervention by decision-makers.¹⁰⁰ Because cultural expectations will influence whether a specific adaptation is considered to carry with it the force of law or social authority, it would be necessary to conduct a broad survey of cultural attitudes across different populations.¹⁰¹ This is beyond the scope of this Article.

Leaving aside the question of whether the insurance is perceived as legitimate by Shenzhen residents, applying the existing social insurance as an adaptation model for climate change appears to offer mixed conclusions. On the one hand, the insurance appears to be relatively economically efficient and potentially equitable, but on the other hand, the social insurance is of questionable effectiveness. Given the initial two billion yuan of investment in the municipal insurance component of the pilot, what more might be done to cost-effectively alleviate future suffering linked to climate change in large municipalities such as Shenzhen?

III. ADAPTING THE SHENZHEN MODEL FOR SUCCESS

In theory, insurance can play an important role in climate change adaptation by increasing disaster risk reduction efforts and compensating the victims of climate change's impacts.¹⁰² Insurance schemes like the nationally funded city-wide model of disaster insurance in Shenzhen alone will not be enough to enhance national socio-economic resilience—they are simply

⁹⁷ See *Catastrophe Insurance Framework of Shenzhen City*, *supra* note 43.

⁹⁸ See Adger et al., *supra* note 93, at 83.

⁹⁹ See *id.* at 84 (citing post-recovery efforts after Hurricane Mitch as reinforcing pre-disaster inequalities).

¹⁰⁰ See *id.*

¹⁰¹ See *id.*

¹⁰² See PRABHAKAR ET AL., *supra* note 92, at 7.

too thin of a response in terms of reducing exposure to hazards. The Shenzhen insurance is an *ex post facto* strategy.¹⁰³ In conjunction with the delivery of the insurance, the region will also need a stronger *ex ante* response to reduce the city's vulnerability to known weather events and perhaps to give more attention to pooling risks with other similarly situated centers.

In March 2015, the global community in the Sendai Framework for Disaster Risk Reduction, which was adopted at the Third United Nations World Conference on Disaster Risk Reduction, recognized the urgency of investing in disaster risk management now to avoid future disaster scenarios.¹⁰⁴ In particular, the framework emphasizes the need for “enhanced work to reduce exposure and vulnerability.”¹⁰⁵ While social insurance products can address concerns over increasing vulnerability of populations that reside in harm's way, this type of insurance is unlikely to reduce exposure to hazards unless it is somehow directly connected to risk reduction efforts. Smarter planning regarding future developments or redevelopments and subsidized risk reduction for known hazards are needed to adapt the Shenzhen model to be a successful adaptation model to incentivize social change.

A. Smarter Planning, Subsidized Risk Reduction, and Penalties for Inertia

What is needed at this juncture is national—or possibly provincial, in the case of federalist governments—climate proofing of various sectors across a city. Prevention of disaster avoids future costs associated with disaster response.¹⁰⁶ Some of this preventative work can be done cost-effectively by climate smart planning so that development is not permitted in flood plains or new developments are built to more robust code standards.¹⁰⁷ Effective planning will rely on exercising political backbone, particularly on the part of local municipalities where many land use decisions are made.¹⁰⁸ Central governments may encourage effective planning through some combination of incentives or penalties, depending on how cooperative a given planning body has been in mainstreaming climate disaster concerns.

¹⁰³ See Li & Ran, *supra* note 45.

¹⁰⁴ See UNITED NATIONS, SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015–2030 ¶ 5 (2015) [hereinafter SENDAI FRAMEWORK], http://www.preventionweb.net/files/43291_sendai_frameworkfordrren.pdf [https://perma.cc/95ZR-MQCC].

¹⁰⁵ *Id.* ¶ 6.

¹⁰⁶ See SENDAI FRAMEWORK, *supra* note 104, at ¶ 11 (addressing the importance of preparation as a means to disaster prevention).

¹⁰⁷ *Id.* at ¶ 30.

¹⁰⁸ See *id.*

Many municipalities rely on some central funding, particularly for the development and maintenance of larger infrastructure projects.¹⁰⁹

In the more typical case, the existing infrastructure may need to be strengthened or enlarged to cope with severe weather events. For example, in the case of the chronic flooding faced by Shenzhen, the city must make rapid strategic investments into appropriately sized water and wastewater infrastructure while also potentially shoring up vulnerable areas such as de-vegetated coastal zones.¹¹⁰ The city may also need to proactively relocate populations that are directly exposed to impacts of natural disasters but who are unable to make personal investments in reducing disaster threats, such as parties living in temporary squatter settlements. All of these government-facilitated programs would contribute to long-term climate change adaptation for the municipality as a whole.

In many instances, individuals, including individual businesses, are unlikely to voluntarily invest in natural disaster risk mitigation because the degree of exposure is perceived as insignificant unless they have experienced a disaster.¹¹¹ While parties may reassess their perceptions about investing in mitigation after a certain level of damage is experienced, it may be too late to secure long-term community resilience. Injured parties with the resources may simply leave the community. This is arguably the story of New Orleans, Louisiana, where individuals and business have failed to rebuild in some flood-devastated neighborhoods and have instead relocated to Texas and other states.¹¹² If enough such parties depart in succession, then the community begins to experience what might be termed “disaster flight.”

Unless numerous *ex ante* steps are taken to prevent known hazards from becoming the precursors to a disaster, insurance will not be able to support long-term socio-economic adaptation because premiums for existing insurance products may be spread too thin to adequately cover city-wide losses. Insurance must be approached as a last resort strategy to allow for recovery from unexpected events. For expected events—such as the col-

¹⁰⁹ See ECON. COMM'N FOR EUROPE, UNITED NATIONS, FINANCING SCHEMES OF TRANSPORT INFRASTRUCTURE 2 (2003) (discussing the importance of government funding to infrastructure projects, particularly on a larger scale).

¹¹⁰ See Coco Liu, *China Bets on “Sponge Cities” to Cope with Flooding and Drought*, CLIMATEWIRE (June 16, 2015), <http://www.eenews.net/stories/1060020275> [<https://perma.cc/PNA9-X6WV>].

¹¹¹ See Paul R. Kleindorfer & Howard C. Kunreuther, *Challenges Facing the Insurance Industry in Managing Catastrophic Risks*, in THE FINANCING OF CATASTROPHE RISK 156 (1999).

¹¹² Greg Allen, *Some Moved On, Some Moved in and Made a New New Orleans*, NPR (Aug. 26, 2015, 4:28 PM), <http://www.npr.org/2015/08/26/434288564/some-moved-on-some-moved-in-and-made-a-new-new-orleans> (observing that New Orleans lost 110,000 people since Hurricane Katrina and that some heavily impacted neighborhoods such as the Lower Ninth Ward have not had residents return).

lapse of poorly constructed buildings during a storm event or the release of untreated waste from containment ponds—national ministries and municipalities should facilitate planning efforts to address known vulnerabilities by providing subsidies for risk reduction. Insurers and particularly reinsurers with a large database of this type of recurring global losses are well positioned to provide support on cost effective mitigation measures.¹¹³ Subsidies for mitigation should create sufficient incentives to assist with what may be difficult physical transitions in communities, such as the changing of building materials or the raising of buildings. For entities with limited capital, such as low-income homeowners, the costs of making changes could be provided through direct government payments. For individuals or groups with existing capital, such as established companies, subsidies might be provided in the form of graduated tax credits.

Where incentives are not sufficient to prod parties into “climate-proofing” assets or relocating assets, penalties may need to be assigned for a failure to act. Because certain parts of a city are more likely to experience damage than other areas, due to geography or density of infrastructure, the timelines for taking action to reduce disaster exposure may vary for different areas of a city.¹¹⁴ For example, open wastewater treatment ponds in a coastal region or an area near a water channel prone to flooding may need to be contained on a shorter deadline than a similar treatment pond on a plateau region, before penalties are incurred. Available investment is obviously limited and public funding should be preferentially given to eliminating disaster hot spots where private investment is unlikely.

In the coming years, the international community, based on the commitments voluntarily entered by States during the Sendai Framework discussions, can expect more systematic disaster risk reduction through the support of organizations such as the Global Facility for Disaster Reduction and Recovery (the “Facility”) that provides assistance from donor states to low and middle income disaster prone states for risk identification, risk reduction, risk preparedness, financial protection, and resilient recovery.¹¹⁵ The Facility provides for *ex ante* funding covering both national and regional disaster risk reduction.¹¹⁶ Among its recent projects are reports on

¹¹³ See CHARTERED INS. INST., *supra* note 3.

¹¹⁴ See PRABHAKAR ET AL., *supra* note 92, at 7.

¹¹⁵ See CITY STRENGTH, WORLD BANK GRP., ADDIS ABABA, ETHIOPIA: ENHANCING URBAN RESILIENCE 46–47 (2015).

¹¹⁶ See GLOB. FACILITY FOR DISASTER REDUCTION & RECOVERY (GFDRR), PILLAR 4 FINANCIAL PROTECTION 1 (n.d.), <https://www.gfdrr.org/sites/default/files/Pillar%204.pdf> [http://perma.cc/SAE5-X95W].

disaster resilience that underscore the need to invest resources now in strengthening urban centers' responses to future climate impacts.¹¹⁷

Ex ante disaster risk reduction is a long-term work in progress. Pragmatically, cities will not be disaster-proofed rapidly, but there must be clear government leadership at both national and municipal levels to support infrastructure transition and changes in community behavior. For low and medium level risks, prevention is more cost-effective than investing in risk transfers.¹¹⁸ Equally important to the investments in *ex ante* risk management will be strategies providing for a broader diversification of risks.¹¹⁹ The next section highlights one such strategy in the form of risk pooling.¹²⁰

B. Global Insurance Pools for Mega-cities

Losses from a catastrophe such as Hurricane Sandy in New York City highlight the financial exposure of mega-cities to disasters.¹²¹ In addition to the bodily injuries, there were substantial property losses and countless business interruption losses.¹²² Recovery from Hurricane Sandy is still ongoing in part because of bottlenecks in the claim adjustment processes.¹²³ A social insurance system with pre-contracted payments for a given trigger event may have eliminated some of the transactional costs of claims adjustment, but underwriting catastrophe insurance for cities—especially mega-cities—remains a risky business for an insurance company when in-

¹¹⁷ See generally GLOB. FACILITY FOR DISASTER REDUCTION & RECOVERY (GFDRR), PILLAR 5 RESILIENT RECOVERY 1–2 (n.d), <https://www.gfdr.org/sites/default/files/Pillar%205.pdf> [<https://perma.cc/86PT-AF7N>] (explaining the ways in which the Facility equips governments with the necessary resources to recover and reconstruct their communities following a natural disaster).

¹¹⁸ See Stefan Hochrainer & Reinhard Mechler, *Natural Disaster Risk in Asian Megacities: A Case for Risk Pooling?*, 28 CITIES 53, 54–55 (2011).

¹¹⁹ See *id.* at 59 (“Diversifying Asian megacity risk . . . would seem to reduce costs.”).

¹²⁰ See *infra* notes 123–141 and accompanying text.

¹²¹ Editorial, *Hurricane Sandy's Rising Costs*, N.Y. TIMES (Nov. 27, 2012), http://www.nytimes.com/2012/11/28/opinion/hurricane-sandys-rising-costs.html?_r=0 (“Gov. Andrew Cuomo’s latest request for federal aid to help New York recover from Hurricane Sandy presents a shattering picture of what a giant storm can do to a dense metropolitan area. The total price tag, he said, would be more than \$42 billion . . .”).

¹²² See Kirk A. Pasich et al., Dickstein Shapiro LLP, *Superstorm Sandy: Emerging Insurance Coverage Issues*, 2013 EMERGING ISSUES 6884, 6884.

¹²³ See Patricia L. Harman, *Host of Factors Contributed to Hurricane Sandy Claims Fallout*, PROPERTY CASUALTY 360° (Oct. 27, 2015), http://www.propertycasualty360.com/2015/10/27/host-of-factors-contributed-to-hurricane-sandy-cla?page_all=1 [<https://perma.cc/JV8S-C4QN>] (describing how different adjusters operated from different basic assumptions and a profusion of incomplete adjustment reports).

sured assets are in close proximity.¹²⁴ Success in a mega-city index market will depend in part on global diversification of risks across a range of locations, and also possibly across a range of type of climate impacts.¹²⁵ For example, insurance scholars have recently observed that insurance losses in American and Australian-Asian markets are not closely linked, so these insurance markets would be better positioned to share risks.¹²⁶

Pooling risk through global insurance pools allows for disaster impacts to be offset across a wide number of actors.¹²⁷ For example, harms in one mega-city such as Shanghai could be offset by risks in a mega-city such as London that is geographically distant from the original harms. Likewise, hurricane risks in New York could be offset within a disaster risk pool by heat waves in Chengdu. Risk pooling for megacities, particularly in Asia, may be especially appropriate for low probability but high damage events.¹²⁸

A number of existing catastrophe risk pools involving disaster prone states might serve as models for diversifying a megacity risk pool. The first multi-country risk pool was set up with the Caribbean Catastrophic Risk Insurance Facility (“CCRIF”) using financial contributions from Canada, the European Union, the United Kingdom, France, Ireland, Bermuda, Japan, the World Bank, and the Caribbean Development Bank.¹²⁹ The sixteen insured countries also pay premiums, which vary according to the costs of rebuilding.¹³⁰ After a trigger event happens, measured on the basis of a ground-shaking incident or a wind speed, funds are quickly provided via reinsurance and capital markets to support immediate relief following a disaster.¹³¹ In the case of a storm that hit several Caribbean countries, fifty percent of the designated funds were disbursed seven days after the original storm impact and the remainder was distributed fourteen days after the disaster.¹³² The money went to protect, and where necessary, rebuild, critical

¹²⁴ See TRISTAN NGUYEN, UNITED NATIONS OFFICE FOR DISASTER RISK REDUCTION (UNISDR), *INSURABILITY OF CATASTROPHE RISKS AND GOVERNMENT PARTICIPATION IN INSURANCE SOLUTIONS 3* (2013).

¹²⁵ See Hochrainer & Mechler, *supra* note 118, at 59.

¹²⁶ See Kousky & Cooke, *supra* note 82, at 222.

¹²⁷ See Dirk Schoenmaker & Georg Zachmann, *Can Global Climate Risk Pool Help the Most Vulnerable Countries?*, BRUEGEL, Dec. 2015, at 6, http://bruegel.org/wp-content/uploads/2015/12/pb-2015_041.pdf [<https://perma.cc/9TGW-F6R5>].

¹²⁸ See Hochrainer & Mechler, *supra* note 118, at 55.

¹²⁹ See *About Us*, CARIBBEAN CATASTROPHIC RISK INS. FACILITY (CCRIF), <http://www.ccrif.org/content/about-us> [<http://perma.cc/4DYE-8ZVY>].

¹³⁰ See *id.*

¹³¹ See *id.*

¹³² *Caribbean Governments Receive US\$12.8M Insurance Payout from CCRIF Following Passage of Tomas*, CARIBBEAN CATASTROPHIC RISK INS. FACILITY (CCRIF) (Nov. 17, 2010), <http://>

infrastructure such as drinking water plants.¹³³ To avoid overcompensation and to encourage system wide risk management, governments participating in the CCRIF have only been permitted to purchase coverage for \$100 million for business interruption losses from a single disaster event.¹³⁴

A second model is the Pacific Catastrophe Risk Insurance pilot designed by the World Bank in conjunction with the Secretariat of the Pacific Community, Japan, the Asian Development Bank, and the Global Facility for Disaster Reduction and Recovery to assist the Marshall Islands, Tonga, Solomon Islands, Samoa, and Vanuatu with post-disaster recovery from earthquake events, including tsunamis and tropical cyclones.¹³⁵ The idea is that by pooling risk across the geographical region, the states will be able to recover more quickly after a disaster.¹³⁶ Two payments have been made under the program since its inception with \$1.9 million going to Vanuatu after Category 5 Cyclone Pam and a payout to Tonga for Cyclone Ian.¹³⁷

Each of these models offers a means for pooling risk across a group of actors who are similarly exposed to certain types of risks and ensures a quick infusion of cash into an economy to address business interruption and losses in key property assets.¹³⁸ In conjunction with risk reducing efforts, states at the national level, in the case of large states such as China, or at the regional level, for smaller states such as Singapore, should explore broader pooling of city-based risks that can be attributed to climate change to increase the reservoir of capital available for disaster responses. Although models such as the Caribbean and Pacific catastrophe pools may not be easily replicated without the support of international insurers, cities of a certain size with similar risk profiles should consider pooling certain types of risks.¹³⁹ For example, thirteen of the twenty most populated cities in the world are port cities that might benefit from sharing risks associated with damage to port infrastructure and port economies.¹⁴⁰

www.ccrif.org/news/caribbean-governments-receive-us128m-insurance-payout-ccrif-following-passage-tomas [https://perma.cc/FX4X-LDWW].

¹³³ *Id.*

¹³⁴ *CCRIF Insurance Policies and Payouts*, CARIBBEAN CATASTROPHIC RISK INS. FACILITY (CCRIF), <http://www.ccrif.org/content/rdfs-faqs> [https://perma.cc/8RM8-MJCD].

¹³⁵ *See* WORLD BANK GROUP, *PACIFIC CATASTROPHE RISK INSURANCE PILOT: FROM DESIGN TO IMPLEMENTATION: SOME LESSONS LEARNED* 9 (2015), [https://www.gfdrr.org/sites/default/files/publication/Pacific_Catastrophe_Risk_Insurance-Pilot_Report_140715\(1\).pdf](https://www.gfdrr.org/sites/default/files/publication/Pacific_Catastrophe_Risk_Insurance-Pilot_Report_140715(1).pdf) [https://perma.cc/GRE6-HWC4].

¹³⁶ *Id.* at 36.

¹³⁷ *Id.*

¹³⁸ *See supra* notes 129–137 and accompanying text.

¹³⁹ *See* WORLD BANK GROUP, *supra* note 135, at 44.

¹⁴⁰ *See* Susan Hanson et al., *A Global Ranking of Port Cities with High Exposure to Climate Extremes*, 104 *CLIMATE CHANGE* 89, 90 (2011).

A successful mega-city pooling of disaster risk would need access to cross-border reinsurance, which has been restricted in some jurisdictions.¹⁴¹ A mega-city pool should also incentivize disaster risk reduction by adjusting premiums to reflect disaster-proofing efforts on the part of a given jurisdiction. In a pool of similarly situated municipalities such as high population port cities, the various city participants may find common cause in promoting best practices and have the expertise to assist each other in implementing these practices.

CONCLUSION

Modern disasters are testing our adaptability as a species. We know with a great degree of certainty each year that climatic conditions are changing and that more and more individuals and companies are facing exposure to potentially catastrophic events. The pilot insurance program in Shenzhen, China, the first large scale social insurance product, is to be applauded as a bold social effort to assist community recovery—particularly for some of the poorest members of the community—in the face of climate change. While this insurance appears to be an efficient and equitable market tool for providing relief for bodily injuries and deaths, there are legitimate questions about whether it will be effective in stimulating the kind of long-term post-disaster recovery that will promote community resilience. This Article concludes by suggesting that states must understand insurance as a last resort adaptation strategy. Before insurance can become effective as an adaptation product for mega-cities, these cities, with the support of government subsidies, must begin the long and politically difficult process of “climate-proofing” through a variety of city-specific programs offering incentives to act and assigning penalties for a failure to act. To the extent that cities choose to continue to offer insurance products for residents, these cities should consider pooling their risk.

In the past century, governing bodies at the local, regional, and national levels have gambled with the outcome of climate change. Numerous global leaders have misunderstood the odds associated with change and have countenanced a great deal of hazardous economic choices that continue to expose millions of individuals across the globe to new risks. It is time for the same governance bodies to improve the survivability odds for these individuals and for generations to come. Insurance is part of a long-term adaptation strategy to soften financial shocks associated with physical devastation, but much work still remains to be done to eliminate known disaster

¹⁴¹ See SCHANZ & WANG, *supra* note 31, at 44.

risk before we can assume, as the insurance industry informs us, that we “are in good hands.”

