ADAPTATION

Cities' response to climate risks

City-level policies have often been unable to limit natural disaster losses. Research on New York City now shows progress in devising flexible adaptation policies that accept uncertainty about future climate-related risks and work around it.

Jeroen Aerts and Wouter Botzen

Almost every month, we can witness the impact of natural disasters on our societies. Storms such as Typhoon Haiyan in the Philippines and Hurricane Sandy in New York City (NYC) have caused billions of dollars of losses and have led to thousands of casualties. Ex-post disaster aid feels like a drop in the ocean for impacted communities. It seems that our current long-term policies to reduce risk from natural hazards are failing to reverse the losses trend. So what to do, knowing that the increase in flood risk is mainly due to our own decisions to develop urban centres in low-lying, exposed floodplains? Future climate change will further exacerbate risks. We need to critically re-think adaptation strategies in the face of uncertain trends in flood risks. Writing in *Global Environmental Change*, Cynthia Rosenzweig and William Solecki[1] evaluate how NYC has developed 'flexible adaptation pathways' to manage climate risk. Hurricane Sandy served as a tipping point to create the political momentum to develop such innovative pathways that acknowledge the uncertainty of extreme events and maintain flexibility to change strategy, while investing in an enduring partnership between scientists and policymakers.

Rosenzweig and Solecki write how Hurricane Sandy triggered massive flooding that caused US$19 billion damage in NYC alone. The hurricane caused an extreme 14-foot storm surge, which inundated flood-prone areas of the city, including parts of Lower Manhattan. The floods caused short-circuiting in low-lying power hubs, causing power outages for millions of households. Subway systems and tunnels were flooded, thousands of buildings were hit and more than 40 people were killed. Several underlying causes are discussed, such as the rarity of the storm, with a probability lower than 1-in-500 years. This is far beyond any 'realistic' policy scenario, as scenarios are mostly based on events that occur on average every 100 years. Moreover, it appeared that the flood maps, which are produced by the Federal Emergency Management Agency, were not accurate, and yet flood insurance and flood-resistant building code policies are based on these maps. Hence, outdated flood risk information made policymakers and NYC inhabitants underestimate the flood risk before Hurricane Sandy hit NYC.

The event in NYC does not stand on its own, as many low-lying cities face increasing risk, and suffer from outdated risk information and a lack of understanding of what measures to take. Insurance data show that global losses due to natural disasters are rising rapidly. Increasing population density in flood-prone coastal zones and megacities as well as climate change are expected to increase the frequency and severity of floods in the future[2,3].

Maintaining the status quo is no longer an option in NYC. Rosenzweig and Solecki demonstrate that Hurricane Sandy surpassed all critical thresholds of acceptable risk. The general public and policymakers not only called for immediate cleaning and rebuilding, but also demanded clever and sustainable investments in risk reduction that allow anticipation of current and future risk. Interestingly, they acknowledge the future is inherently uncertain, including climate change and socioeconomic trends, and therefore we cannot predict when, and by how much, the next event will cross acceptable thresholds. Following other studies[4,5], this one shows how NYC has embraced a policy transformation in terms of flexible adaptation pathways, which anticipate that uncertainty. The pathways are not fixed and adaptations are re-evaluated over time; when new risk information becomes available, the adaptation pathway can be adjusted. In practice, the proposed adaptation policies for NYC include reducing flood risks to infrastructure, buildings and highly exposed communities through small-to-medium scale flood protection strategies (for example, levees), regulatory approaches (building codes) and

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29 October 2012. Flooding from Hurricane Sandy in New York City, USA.

improved insurance programmes. Results of existing benefit–cost analyses support such flexible strategies for NYC[6].

Rosenzweig and Solecki also address important barriers to the implementation of flexible adaptation pathways. One is the cultural bias towards 'toughness', with fast rebuilding preferred to retreat in high-risk areas. It follows the instability of political systems changing with every mandate (usually on a 4–5 year interval), whereas adaption processes, and the implementation of protective measures such as levees or new building codes, take decades. Another barrier is the fact that adaptation requires reliable financing schemes, which are difficult to guarantee over long time periods. Finally, the institutional fragmentation that characterizes rebuilding and adaptation efforts — a process spread over different government layers, such as city, state and federal levels — has hindered a regionally focused approach. Such an approach is needed to ensure that the implemented solutions are consistent — for example, the design of city building code policies should be compatible with federal flood insurance regulations.

Using existing methods, Rosenzweig and Solecki identify three critical dimensions — multidimensionality, interdependency and intertemporality — that should be integrated into both the research and the practice needed to develop flexible adaptation pathways, and how these have been addressed in NYC[7,8]. Multidimensionality means the city acknowledges that climate adaptation is not a separable policy, but it is integrated into other policies, such as public health and developing green buildings. Interdependency refers to coordinating adaptation across spatial scales, sectors and jurisdictional boundaries. Intertemporality refers to the dynamics of adaptation, which evolves over time, and requires indicators and monitoring systems that incorporate the most recent risk information to evaluate investments.

Why promote guidelines for flexible pathways at the city level? Rosenzweig and Solecki show cities are not only in the frontline of suffering climate-related impacts, but also provide first aid to solve the problems. Cities have a long experience in addressing multiple environmental stresses (water supply, waste disposal and air quality), and climate change is now added to the equation. By forming networks, such as C-40 Cities (http://www.c40.org/) and Connecting Delta Cities (http://www.deltacities.com/home), cities can learn best practices from each other, and communicate with state- and federal-level governments about the need for climate preparedness.

Implementing the flexible adaptation pathways as sketched by Rosenzweig and Solecki is only viable through a cooperation of scientists and other stakeholders that provide adequate risk information to policy. Under the pressure of rebuilding NYC after Hurricane Sandy, much has been achieved in this respect. The key questions now are how to maintain flexibility in policy, how to fund adaptation and how to constantly work on the science–policy interface, without needing another disaster to trigger action? ❐

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SOIL CARBON

Resisting climate change

Increasing temperatures are expected to increase decomposition rates in soils, potentially reducing ecosystem carbon storage. Research now indicates that — in a tropical montane forest — soil carbon stocks are unaffected by higher temperatures despite substantially increased rates of CO_2 release from the soil.

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Soils contain more carbon than the atmosphere and all plant biomass combined. In short-term experiments (~1–10 years duration), warming has been shown to increase the rate at which this carbon is released from soils to the atmosphere. Therefore, as global temperatures increase, there are fears that more CO_2 may be released to the atmosphere, further increasing temperatures, which in turn could result in more CO_2 being released from soils, and so on. Writing in *Nature Climate Change*, Giardina *et al.*[1] report that they have tested this important theory by investigating how soil carbon stocks changed with temperature along an altitudinal gradient on the eastern slope of the Mauna Kea volcano in Hawaii. Across this gradient, the tree species and soil type were relatively constant, providing an excellent opportunity to investigate how temperature affects soil carbon storage.

Their results suggest that, while the initial stages of decomposition do indeed proceed faster in the warmer sites, this does not translate to any clear reduction in soil carbon stocks (Fig. 1). Furthermore, based on radiocarbon dating, Giardina *et al.*[1] suggest that the lack of a change in soil carbon stocks is not simply caused by greater rates of soil organic matter decomposition in warmer soils being balanced out by greater soil carbon inputs from these more productive forests. The average age of the organic matter — which provides an indication of how quickly carbon cycles through a soil, referred to as its residence time — was not related to either temperature or forest productivity. Therefore, it seems that, across this altitudinal gradient, another