EMBARGOED: NOT FOR PUBLICATION, BROADCAST, OR TRANSMISSION UNTIL:

THURSDAY, NOVEMBER 11, 2010 | 9:00 AM | WASHINGTON, D.C. TIME

THURSDAY, NOVEMBER 11, 2010 | 3:00 PM | GENEVA TIME

Natural Hazards, UnNatural Disasters

The Economics of Effective Prevention

Overview

The adjective "UnNatural" in the title of this report conveys its key message: earthquakes, droughts, floods, and storms are *natural hazards*, but the *unnatural disasters* are deaths and damages that result from human acts of omission and commission. Every disaster is unique, but each exposes actions—by individuals and governments at different levels—that, had they been different, would have resulted in fewer deaths and less damage. Prevention is possible, and this report examines what it takes to do this cost-effectively.

The report looks at disasters primarily through an economic lens. Economists emphasize self-interest to explain how people choose the amount of prevention, insurance, and coping. But lenses can distort as well as sharpen images, so the report also draws from other disciplines: psychology to examine how people may misperceive risks, political science to understand voting patterns, and nutrition science to see how stunting in children after a disaster impairs cognitive abilities and productivity as adults much later. Peering into the future, the report shows that growing cities will increase exposure to hazards, but that vulnerability will not rise if cities are better managed. The intensities and frequencies of hazards in the coming decades will change with the climate, and the report examines this complicated and contentious subject, acknowledging all the limitations of data and science.

Four main findings

First, a disaster exposes the cumulative implications of many earlier decisions, some taken individually, others collectively, and a few by default. A deeper questioning of what happened, and why, could prevent a repetition of disasters. Several factors usually contribute to any disaster, some less obvious than others. The immediate cause of a bridge or building collapse may be a mudslide, though poor design or construction may have also contributed. But the underlying cause may be denuded hillsides that increased sediment flows (as in Haiti), or poor urban planning that put the bridge or building in harm's way. Symptoms are easily mistaken for cause: denuded hillsides may result from desperately poor people depleting the vegetation to survive, or from logging concessions that encourage tree cutting but not planting. Effective prevention measures are therefore not always "obvious."

Second, prevention is often possible and cost-effective. Studies for the report examined the costs and benefits of specific prevention measures that homeowners could take in hazard-prone areas

of four low- and middle-income countries. Prevention pays for assumed (but reasonable) costs and discount rates. Other prevention measures are embedded in infrastructure (such as adequate drainage ditches). The report examines government expenditures on prevention and finds that it is generally lower than relief spending, which rises after a disaster and remains high for several subsequent years. But effective prevention depends not just on the amount but on what funds are spent on. For example, Bangladesh reduced deaths from cyclones by spending modest sums on shelters, developing accurate weather forecasts, issuing warnings that people heeded, and arranging for their evacuation. All this cost less than building large-scale embankments that would have been less effective.

Third, many measures – private and public – must work well together for effective prevention. Low-lying areas around Jakarta illustrate the complexity of ensuring this: residents raise the plinth of their houses to protect against floods, but they also draw water through borewells causing the ground to subside. Even knowing this, a person has no choice if the government does not provide piped water. So, the prevention measures an individual undertakes also depend on what the government does—or fails to do—and vice versa.

That many measures do not work well together in poor countries explains why they have more disasters. The poor may know the hazard risks but depend more on public services that are often inadequate. They live near work on cheaper land exposed to hazards if buses are unreliable, while the rich with cars have better alternatives. The poor would willingly move to safer locations if their incomes rose or if public transport became more reliable. Many governments in poor countries struggle to provide such services, and until they do, the poor will remain vulnerable.

Fourth, the exposure to hazards will rise in cities, but greater exposure need not increase vulnerability. Large cities exposed to cyclones and earthquakes will more than double their population by 2050 (from 680 million in 2000 to 1.5 billion in 2050). The increase will differ by country and region. Vulnerability need not increase with exposure if cities are well managed, but the projected increase in exposure underscores the enormous task ahead.

Urban growth is not the only concern. Climate change has received much attention, and there are urgent calls for immediate action because the effects of climate change are cumulative and felt much later. The *2010 World Development Report* discusses the implications of climate change in detail; this report is limited to its *direct* effects on hazards. One estimate of the increase in damage associated with changed tropical cyclone activity as a result of climate change is between $28 and $68 billion annually by 2100. This represents an increase of between 50 and 125 percent over no climate change. There is considerable uncertainty around these long-term projections, reflecting the limits of the data and the climate models that generate them. The damage is in "expected value" terms, but averages hide extremes: a very rare and powerful cyclone could strike a highly vulnerable location causing extremely high damages. And the effects are likely to be concentrated: several small island countries in the Caribbean are particularly vulnerable.

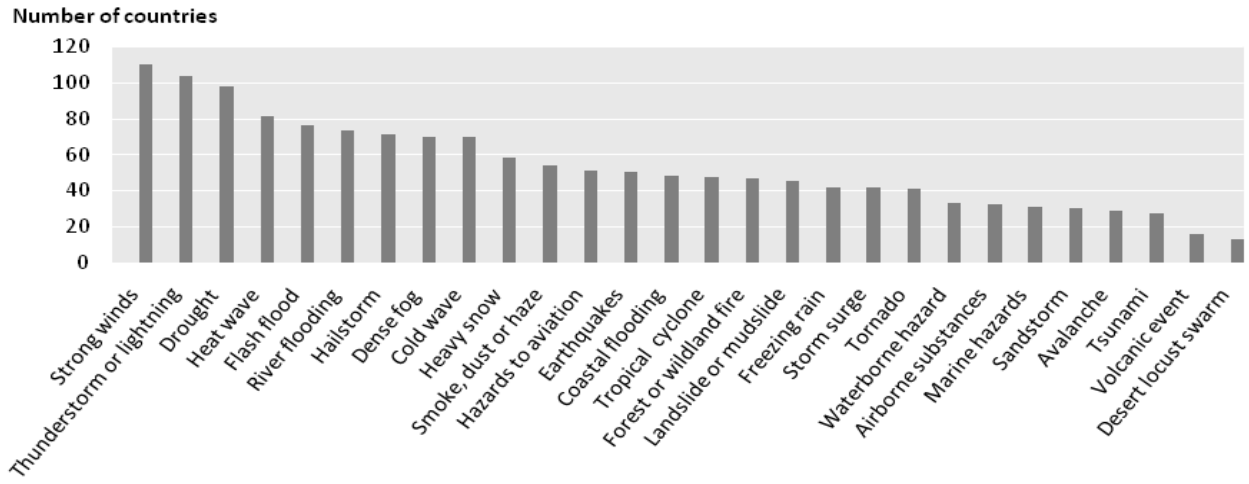
These four findings are not actionable prescriptions. Many people must do numerous things better, but getting them to do so is the challenge. A successful policy response for effective prevention includes information, interventions, and infrastructure. Underpinning this policy

response is the role of "institutions," without which any policy response would be ineffectual. Governments can do much to promote prevention—in line with the policy implications outlined next.

Four policy implications (plus one for donors)

First, governments can and should make information more easily accessible. People are often guided in their prevention decisions by information on hazards, yet the seemingly simple act of collecting and providing information is not easy. Figure 1 shows how few countries collect and archive data on hazards – even though technological advances such as the abundance of free, simple, and open source software (for example, PostGIS, Geoserver, Mapserver, the GeoNode.org project) make collecting and sharing information easy.

Figure 1. Number of countries that archive data for specific hazards



Source: World Meteorological Organization 2006.

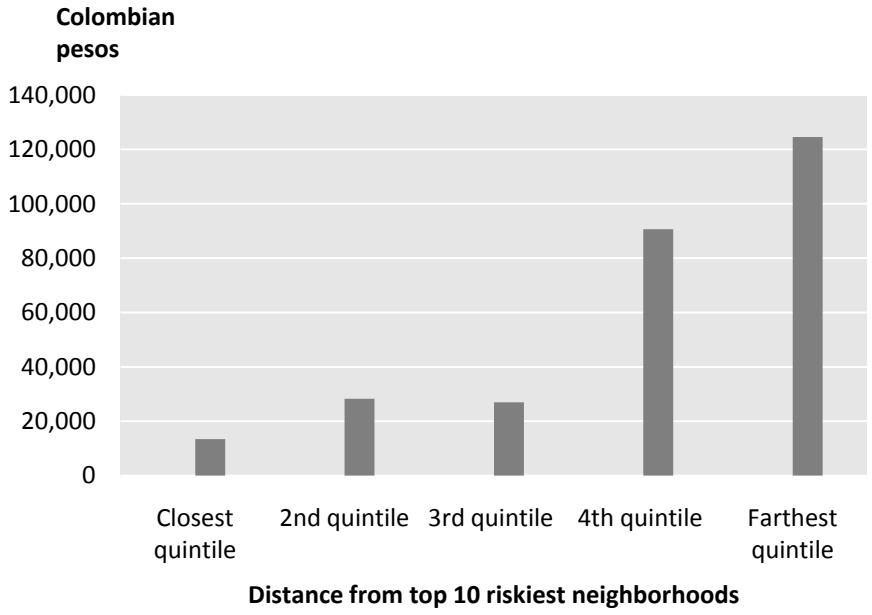
And where information is collected, it is not always shared, even though sharing information on hazards involves relatively little expense because some government agencies already collect and analyze data on hazard risks. Background papers for this report had difficulties obtaining disaster and related data from various public agencies and universities, even though donors often funded the collection and automation of disaster data. Sometimes "security, commercial, and defense" reasons are invoked, but only a few security interests are legitimate. Sometimes commercial interests take precedence over public good aspects.

So, the importance of making information about hazard risks available cannot be overemphasized. Perhaps because of this significance, the political will to not have information on rising levels of risk publicized is often strong. For example, even though FEMA in the United States has updated coastal flood maps for the U.S. Gulf, it cannot get coastal communities to accept them because the information would reduce property prices. Systematic mechanisms for tracking information related to the changing nature of risk, and translating it into risk-related

property valuations, would go a long way to increase the incentives for prevention. Making maps of flood plains and seismic fault lines easily accessible would make developers and property owners more aware of the risks—and more motivated to build appropriately. Collecting data on weather and climate is also integral to producing accurate forecasts.

Second, governments should permit land and housing markets to work, supplementing them with targeted interventions when necessary. When land and housing markets work, property values reflect hazard risks, guiding people's decisions on where to live and what prevention measures to take. Detailed empirical work for this report matched some 800,000 buildings in Bogota that differed in their exposure to seismic risk to a range of characteristics (such as size, construction quality, distance from the city center, and whether residential, commercial, or industrial). Because the only difference among comparable properties is their level of hazard risk, this allowed assessing whether property values are lower in riskier areas. Figure 2 shows that they are, suggesting capitalization of dis-amenities from hazard risk.

Figure 2. Property prices for comparable properties are higher in locations farther from earthquake risk in Bogota



Source: Lall and Deichmann 2009.

But markets, when smothered, dampen the incentives for prevention. In Mumbai, where rent controls have been pervasive, property owners have neglected maintenance for decades, so buildings crumble in heavy rains. Rent controls are not unique to Mumbai or developing countries. Rent control laws have remained in place in some form in New York City since 1943, where there are currently about a million rent-regulated and 50,000 rent-controlled apartments. As recently as 2009, legislation was passed in New York that limits the ability of landlords statewide to increase rents. Such laws are expected to return to regulation many household units previously attracting market rents. They exist in about 40 countries, including many developed

countries. And rent controls are not the only market disortion. Real estate transactions in many countries incur a tax on sales, not on owning property. But taxing transactions reduces property sales and encourages undervaluation. And restrictions on cement prices and imports can create black markets and exorbitant prices, so that adulterated cement ends up weakening structures.

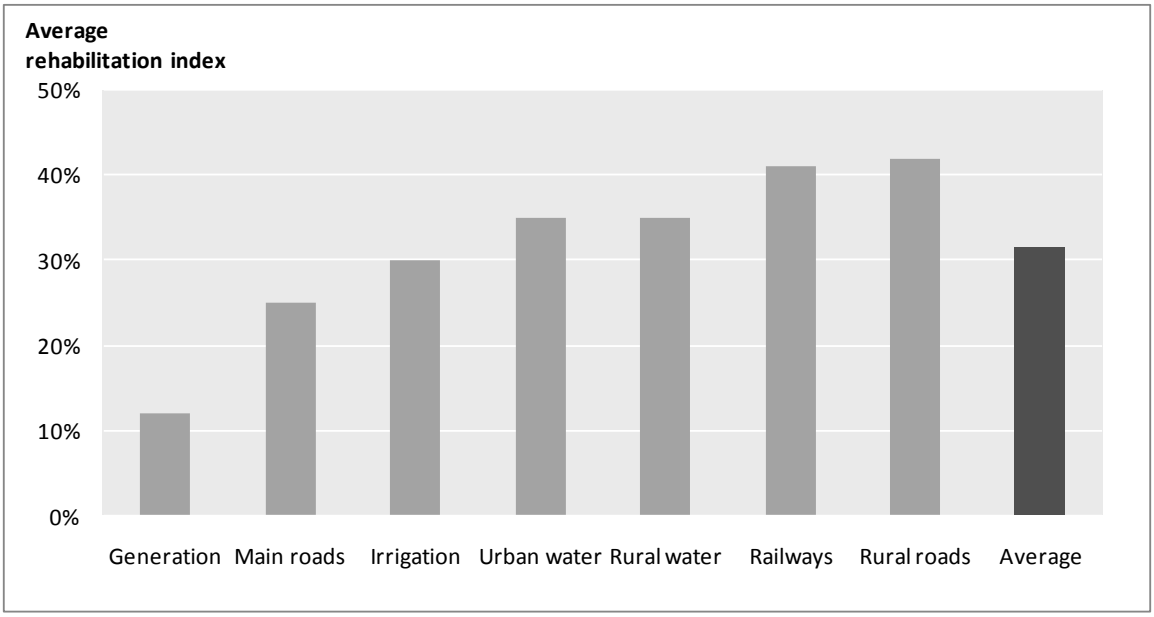
Getting land and rental markets to work can go a long way to inducing people to locate in appropriate areas and take preventive measures. But this will not be a straightforward task. Nor will it be easy to remove the panoply of market distortions because many benefit vested interests. And knowing what to change first is not obvious. Past policies weigh heavily on the present: many structures now standing were built earlier, and defects are difficult to detect and harder to remedy. A corollary is that correcting policies now will not result in immediate improvements, though correcting them sooner would be better than delaying. Where new construction dominates, as in developing countries' urban areas, this legacy is less of an issue, but wealthier countries also bear this burden: mispriced insurance (premia too low because of populist pressures on a regulated industry) has led to overbuilding along the hurricane-prone U.S. coastline.

The poor bear the brunt of the cumulative effects of such policies (tax structure, city financing arrangements, and so on) which produce only a limited and unresponsive supply of affordable, legal land sites for safer housing. Governments could greatly expand the choices of the poor – who often locate in dangerous areas and slums exposed to hazards –but this is more subtle than dictating what they should choose. Poor households prefer to have easier access to jobs, even though this may imply living in slums on riverbanks prone to flooding or on hilltops subject to mudslides. In some cases, security of property (clear titles often help) allows people to invest in prevention measures. When the social consequences of settling in hazardous zones are so adverse, the correct response is for governments to make targeted interventions. This could include making land available in safer locations—along with adequate and reliable public transport and other services so that people remain connected to their jobs.

Third, governments must provide adequate infrastructure and other public services, and *multipurpose infrastructure holds promise.* Much prevention is embedded in infrastructure, but effectiveness depends on quality. Infrastructure needs maintenance: fixing potholes in the road before the winter or the rains; painting steel bridges before they weaken through corrosion; inspecting and fixing cracks in concrete bridges. All engineers know this, but they do not always obtain budget appropriations—even in the United States, where the 2007 bridge collapse in Minneapolis drew attention to such neglect.

Spending should go down a list arranged in descending order of (economic) rates of return. But when subject to arbitrary budget spending limits and lumpiness, low-return spending often gets put ahead of postponable high-return spending. Since maintenance can be postponed, it gets deferred—repeatedly—until the asset crumbles. Drainage ditches, once built, are not adequately maintained and become clogged; so rains result in floods that drown the poor. Other less obvious public services include reliable city transport, and these require better—not always more—public spending. For example, about 30 percent of infrastructure assets of a typical African country need rehabilitation, and just $0.6 billion on road maintenance would yield $2.6 billion in annual benefits (figure 3).

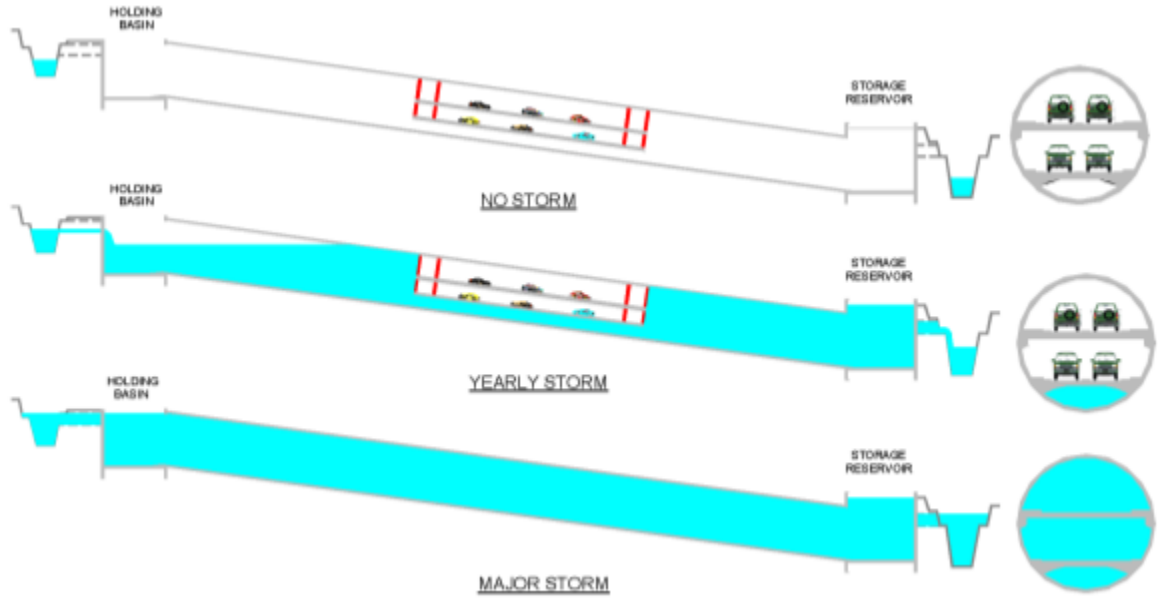
Figure 3. Underspending on maintenance implies an enormous infrastructure rehabilitation backlog in sub-Saharan Africa



Note: The rehabilitation index shows the average percentage across countries of each type of infrastructure that is in poor condition and thus in need of rehabilitation.
Source: Briceño-Garmendia, Smits, and Foster 2008.

Governments must ensure that new infrastructure does not introduce new risk. This is particularly important since, in many developing countries, infrastructure investment—long-lived capital stock—is likely to peak in the coming few decades. Locating infrastructure out of harm's way is one way of doing so. Where that may not be possible, another way is to execute multipurpose infrastructure projects, such as Kuala Lumpur's Stormwater Management and Road Tunnel (SMART). Floods from heavy rains are a hazard, and the 9.7 kilometers long $514 million tunnel has three levels (figure 4), the lowest for drainage and the upper two for road traffic. The drain allows large volumes of flood water from the city's financial district to be diverted to a storage reservoir, holding pond, and bypass tunnel. Combining the drain with the road has two advantages: it ensures maintenance of a drain that otherwise would be used only sporadically, and it costs less than building each separately.

Figure 4. Three modes of operation of the SMART Tunnel



Source: Mott MacDonald 2010.

Infrastucture, even when well designed, constructed, and maintained, cannot always prevent disasters. Governments must, therefore, pay heed to a subset of "critical infrastructure" that once selected, is subject to higher than usual "margins of safety" (the extra strength that engineers build into designs). Such critical infrastructure must be identified before a disaster to ensure its adequacy. But what is critical is situation specific—safe schools serve as cyclone shelters in Bangladesh, but hospitals (not schools) may be more critical in Turkey to treat crushed limbs when buildings collapse in earthquakes. And governments must be careful about keeping the list short: when it includes too many assets, the costs rise without commensurate benefits. Even the United States encounters difficulties in keeping critical infrastructure manageably small, and other governments will undoubtedly discover this as well.

Fourth, good institutions must develop to permit public oversight. Good institutions both reflect and create prosperity, and one robust finding of this report is that countries with well-performing institutions are better able to prevent disasters, including reducing the likelihood of disaster-related conflict. But institutions transcend specific entities. Parliaments, media, business associations, and the like function differently across countries—even if they have similar legal authority and responsibilities.

Fostering good institutions means letting evolve a messy array of overlapping entities (the media, neighborhood associations, engineering groups) that may not all have lofty motives but nevertheless allow divergent views to percolate into the public consciousness. Permitting dissent allows the public to be informed and involved when alternative proposals and opposing views compete for their support. Public involvement and oversight ensure that good ideas are considered even if they are unusual (Kuala Lampur's dual-use drain and car tunnel). Such

oversight also encourages communities to experiment with, and to devise, their own sustainable arrangements that promote prevention.

Where institutions have been suppressed, results are discouraging. Storm damage is more severe in Haiti than in the adjoining Dominican Republic. Deforestation is the visible difference (figure 5) but the quality of institutions is the less visible one. Haiti's institutions and communities have withered from decades of misrule. Vibrant communities help ensure that trees are not thoughtlessly felled and that saplings planted will grow. Even if the interest of uplanders who cut the trees may diverge from lowlanders who get the mud flows, communities bridge these differences and manage the fair use of the commons. Prosperity ultimately depends on rebuilding the trust and social capital that was lost even before the earthquakes and hurricanes struck.

Figure 5. The visible border between Haiti and the Dominican Republic

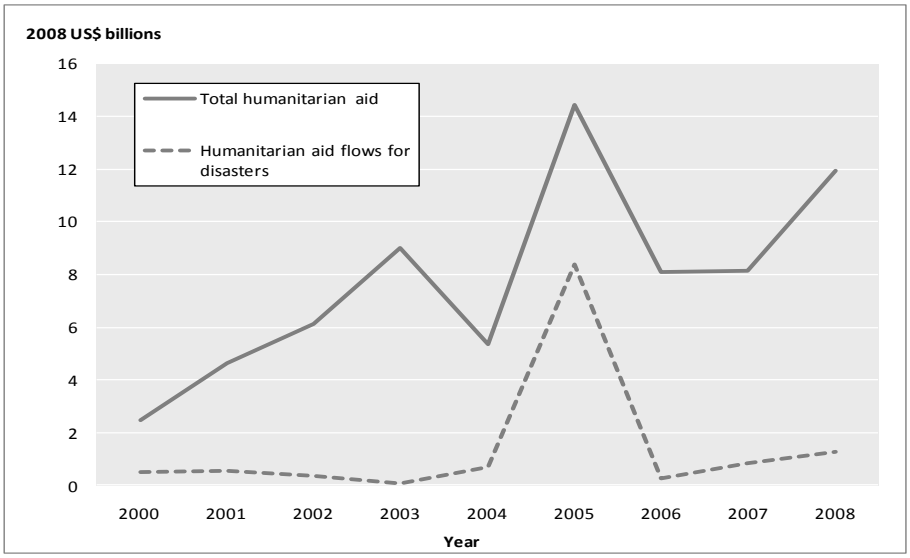
Source: National Geographic.

Often, institutions are linked to democracy, but this report finds that it is not the label of democracy or dictatorship that matters. Good institutions are associated with political competition more than voting alone (the conventional understanding of democracy). Across both nondemocracies and democracies, the existence of "institutionalized" political parties—parties that allow members to discipline leaders who pursue policies at odds with member interests—is significantly associated with reductions in disaster mortality. The mortality from earthquakes falls by 6 percent for an additional year of competitive elections, and by 2 percent when the average party age rises by a year. Such systems are therefore more likely to respond to citizens' needs.

Preventing disasters requires many public and private agencies to work well together, and governments could play an institutional role in this. But there is no single recipe for strengthening institutions; a wide variety of political systems can serve the purpose. But encouraging a diverse set of organizations that facilitate collective action by large groups of citizens will allow them to press more effectively for the spread of information, the availability of prevention measures and alternatives, and their cost-effectiveness.

And fifth, donors have a role in prevention as well. The report's overarching theme is that not enough is being done on prevention. Donors usually respond to disasters after they strike: about a fifth of total humanitarian aid between 2000 and 2008 was devoted to spending on disaster relief and response (figure 6).

Figure 6. Disasters receive about a fifth of total humanitarian assistance



Note: Humanitarian aid is "an intervention to help people who are victims of a natural disaster or conflict meet their basic needs and rights," while official development assistance (ODA) is "money spent on development (education, health, water supply and sanitation, agriculture, and so on) and humanitarian assistance by members of the OECD Development Assistance Committee."
Source: World Bank staff based on data from the Financial Tracking System (FTS) of the UN Office for the Coordination of Humanitarian Affairs.

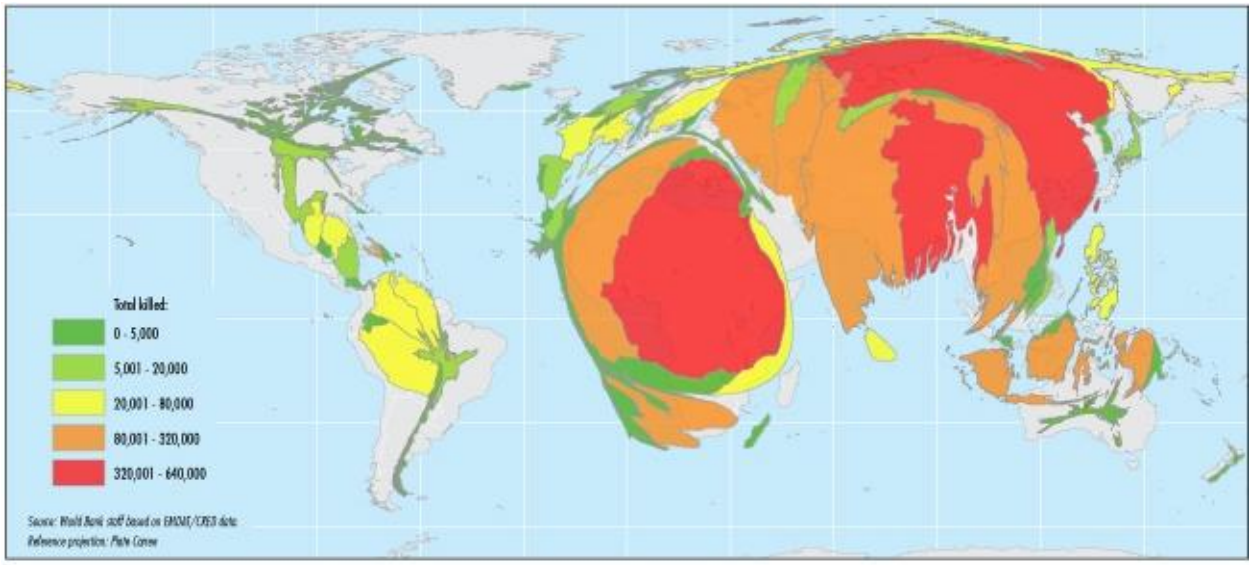
The share of humanitarian funding going to prevention is small but increasing—from about 0.1 percent in 2001 to 0.7 percent in 2008 (Harmer and others 2009). However, prevention activities often imply long-term development expenditures whereas the focus of humanitarian aid – already a tiny part of official development aid – is immediate relief and response. Donors aiming at mainstreaming prevention in projects could earmark official development aid (rather than humanitarian aid) for prevention-related activities. And such aid, if used effectively, could reduce issues arising from the Samaritan's dilemma: the inability to deny help following a disaster to those who have not taken sufficient prevention measures.

In addition to these policy implications, readers may find much of interest and use in the report, summarized in the rest of this overview.

Disaster data patterns revisited

There have been 3.3 million deaths from natural hazards since 1970, or about 82,500 a year, with large year-to-year fluctuations and no pronounced time trends. Droughts are the deadliest of the four hazard categories (earthquakes, floods, and storms are the others) and poor countries suffer disproportionately—almost 1 million people died in Africa's droughts alone. Poor countries withstand the worst of disaster deaths (map 1).

Map 1. Deaths shrink Asia and the Americas—but expand Africa



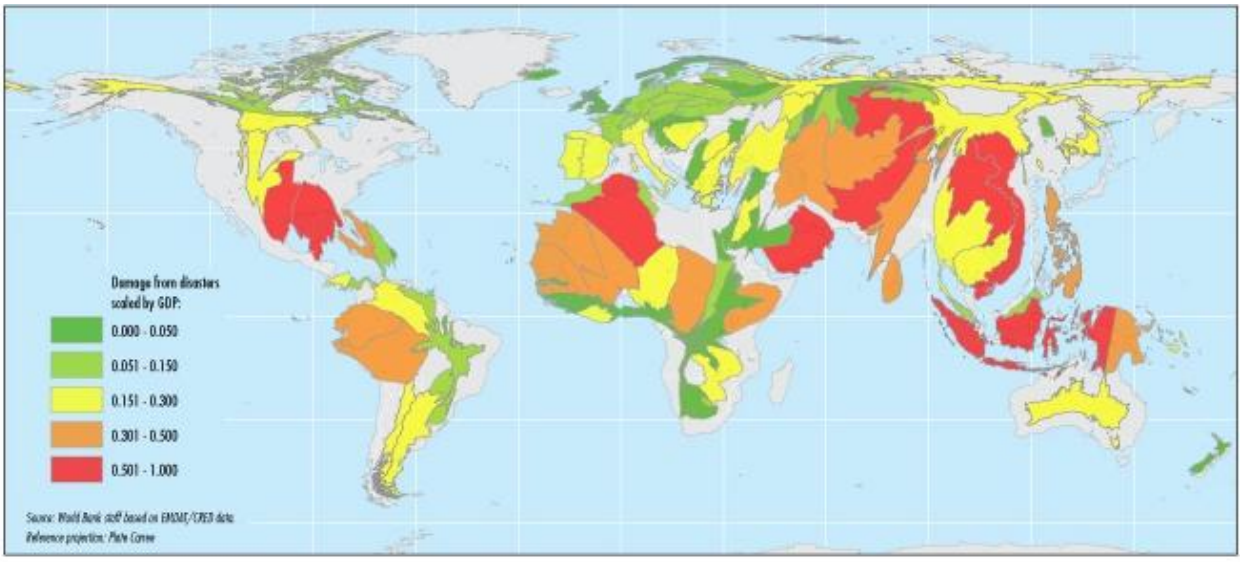
Note: Areas reflect cumulative deaths from disasters for 1970–2010.
Source: World Bank staff based on EM-DAT/CRED.

Despite the avoidable deaths, the absence of a pronounced upward trend suggests the picture is less bleak than it first appears: exposure is rising rapidly (such as poor countries' population, both total and urban) yet deaths would trend down if scaled by the relevant population. So, there has been some effective prevention.

Data on property damage are less comprehensive than those on deaths, but damage from all hazards between 1970 and 2008 totaled $2,300 billion (in 2008 dollars), or 0.23 percent of cumulative world output. Damages fluctuate with a modest but discernable upward trend even when adjusted for inflation. They vary by hazards, with earthquakes and storms causing the most damage. And they are disproportionately high in middle-income countries. Again, the data suggest some effective prevention: if damages are scaled by GDP (globally or by country), they generally trend down.

Even when scaled by output, poor countries with few assets incur little damage, and rich countries (with more capital) effectively prevent damage. Middle-income countries incur the greatest proportional damage (map 2), suggesting why absolute damage has been rising.

Map 2. Damages shrink Africa but expand middle-income countries



Note: Areas reflect cumulative damage from disasters scaled by GDP for 1970–2008.
Source: World Bank staff based on EM-DAT/CRED.

Institutions that prevent damage develop more slowly than assets as countries urbanize and prosper. But this is not immutable: even poor countries can undertake effective prevention, and more can rise to the challenge of doing so.

Disasters' many effects

A disaster obviously hurts those affected. It also spares many in the affected area, yet those spared may be indirectly affected. The village tinker's and tailor's businesses suffer when a cyclone spares their premises but destroys their customers' crops. And such indirect effects extend beyond the affected area, which is linked to undamaged areas through commerce. These indirect effects are often—but not always—adverse. Disentangling the effects is difficult, but clarity of concepts can help, starting with measurement.

How much output falls in the affected area, and for how long, has been controversial. Many factors (simultaneous changes in commodity prices, terms of trade, exchange rates) affect output, and studies differ on whether and how these are taken into account when measuring the effect of a disaster. A disaster may affect only a small part of a country, so it may not reduce national output to the same extent as in the affected area. Studies for this report find that national output always falls after a severe disaster, but (depending on the hazard) sometimes rises after a mild one. An earthquake reduces output, but subsequent reconstruction increases economic activity—though people are obviously worse off. Economic growth is output's rate of change, so even if

output recovers only to its former level after falling, growth (for a brief period) would be higher than pre-disaster rates.

Output does not measure peoples' well-being, especially following a disaster. And not everyone is affected equally—even in the affected area. Farmers who have not lost their crops get higher prices if overall harvest were lower. So the indirect effects—especially in the area outside the disaster zone—are not all adverse.

Governments often assess the damage after a disaster, and such assessments differ in scope, purpose, and technique. The report discusses the conceptual and practical issues in measuring damage and the direct and indirect effects from a disaster. Measuring damage is tricky, prone to both overestimation (for example, double counting) and underestimation (it is difficult to value loss of life, or damage to the environment). Biases also affect the accuracy of estimates, especially when the prospect of aid affects incentives.

Accurate measurement is more likely when its purpose is clear, though some items of interest cannot be measured. Damage assessments have multiple and often overlapping purposes. They could guide government relief (such as how much to spend on alleviating the victims' suffering, knowing that other spending must be cut or taxes raised). They could show how to hasten economic recovery or identify specific measures to improve prevention. This report examines the conceptual and practical feasibility of meeting each purpose.

People do not wait for help to begin repairing their homes and rebuilding their lives, but the poor, with nothing to fall back on, may require help. The government often provides transfers in cash and kind, but "compensation" is a misnomer because the amounts (typically less than twice per capita GDP) are usually less than what people have lost. The government's fiscal situation limits these transfers because even if it could borrow, the debts must be later serviced. So, knowing the disaster's medium-term fiscal implications would be more useful than measuring the damage to private property. If relief and recovery spending displace maintenance of infrastructure, as they often do, the deaths and damage from future disasters would rise.

Recovery requires that commerce resume, and this involves restoring the affected area's links with the rest of the economy. It is in the self-interest of people and private firms up and down the supply chain to repair these links (banking, trucking)—but physical infrastructure (roads, bridges, railways) is often the government's responsibility. Assessing damage to public infrastructure is urgent, and governments must quickly decide what, where, and whether to rebuild. This decision will in turn affect individual decisions to rebuild. Who in government decides depends on the country's administrative structure, and the people affected are best placed to guide the choice of which road or bridge to repair first.

A disaster's effect on an economy's output, or on the government's budget, is not the same as its effect on people's health and well-being. A disaster undoubtedly reduces the well-being of those affected—and even if survivors recover and consume at their earlier levels, they will have suffered in the immediate aftermath.

Many studies have examined how disasters affect people in the short run, and this report complements those studies with others that find longer lasting adverse effects on schooling,

cognitive abilities, and mental health. Some survivors are pushed over the edge and never completely recover: widespread droughts in Africa result in stunted and malnourished children, with permanent adverse effects. An effective safety net can reduce these consequences, but not every safety net is effective.

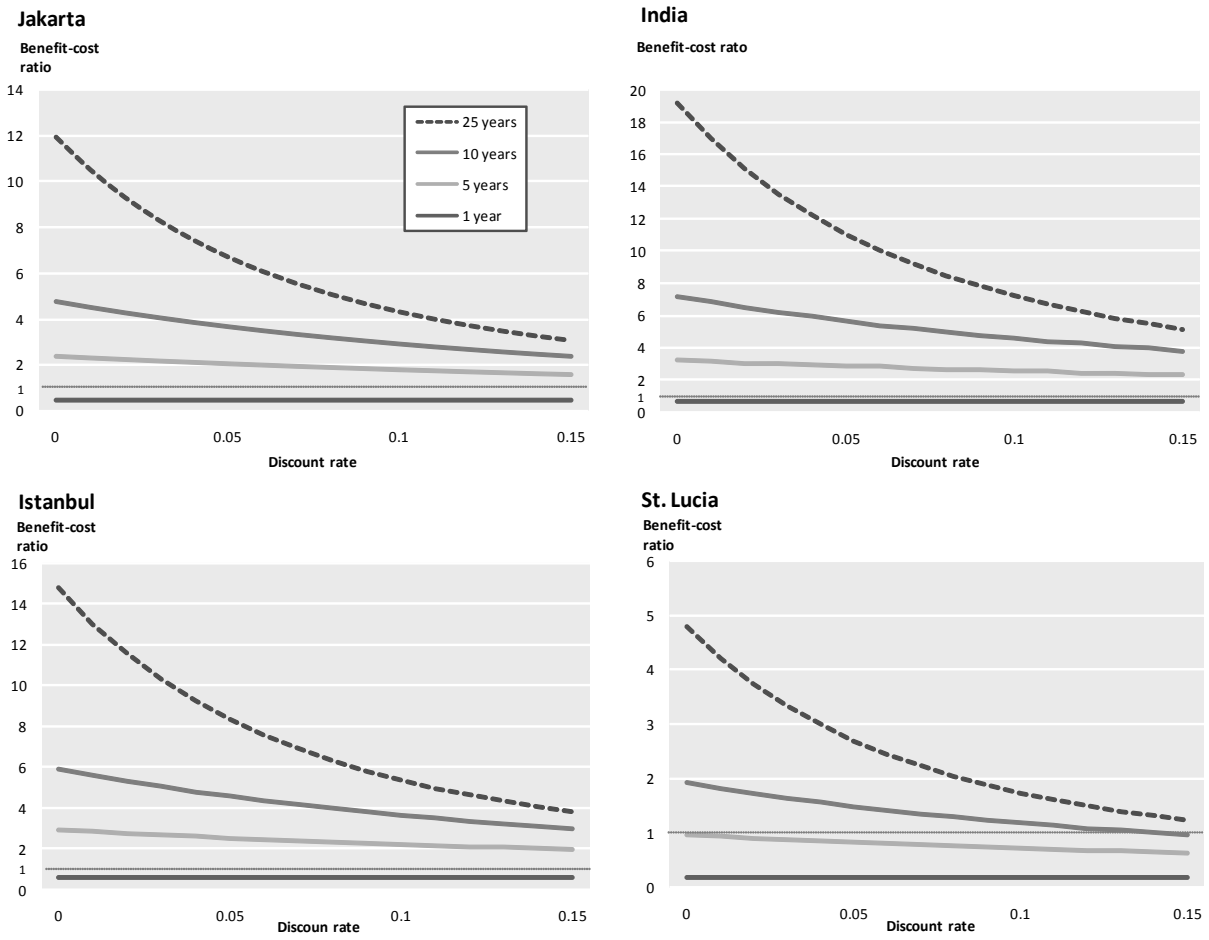
The literature has long noted that disasters and conflicts are connected. Hazards, particularly earthquakes and droughts, tend to prolong conflicts, but good institutions reduce the likelihood of their erupting. Such institutions are typically associated with democracy and good governance—factors also associated with prosperity. This report finds that the link is through political competition rather than voting alone. Do disasters increase scarcity and thus conflict? Or do they create an opportunity for peace, as in Aceh? Either is possible, and good institutions make the better outcome more likely.

Prevention by individuals

The analytical framework of prevention, insurance, and coping has proved useful in many settings, and the report is structured around these concepts, distinguishing individual choices and collective decisions (at different levels of governments). People choose how much prevention to undertake (consciously or by default), how much insurance to purchase, and how much residual risk to bear through coping. Is individual prevention adequate and effective?

People undertake prevention to the point where expected benefits (avoiding losses) exceed the costs – subject to their budget constraint (figure 7). But people differ and everyone chooses differently. Such differences do not necessarily imply that some choose badly, but it is reassuring when large numbers take prevention measures that seem well justified. Rates of returns for several commonly-used prevention measures—such as raising the plinth in flood-prone Jakarta, or protecting windows and doors against wind and rain damage in the Canary Islands—show that some measures are warranted but not all.

Figure 7. Private preventive measures pay



Note: Key prevention measures for which benefit-cost ratios were calculated are: elevating a house by 1 meter to reduce damage from floods (Jakarta); protecting windows and doors and upgrading roofs to prevent hurricane damage (Canaries and Patience, St. Lucia); retrofitting buildings to increase quake resiliency (Istanbul); flood-proofing a brick house (Rohini River Basin, Uttar Pradesh, India).
Source: IIASA/RMS/Wharton 2009.

One person's choice may puzzle another: many live in exposed areas known to be hazardous—whether in poverty in Bangladesh or in affluence along the Florida coast. Recent theories and experimental findings show that people sometimes misperceive risks and may not always act in their own best interests. But there also are more prosaic explanations involving tradeoffs such as proximity to work and access to such conveniences as public transport, given limited budgets.

Living in riskier locations is cheaper for the individual and allows spending on other necessities (food, children's schooling), so the poor face difficult choices. Safer structures could be built in risky areas (on hill slopes, in seismic areas) with sufficient knowledge, care and expense. But when a person's ownership of property is not secure, the possibility of eviction or demolition erodes the incentive to invest in safe structures. A study of 1.2 million land titles distributed in 1996 in Peru finds that land titling is associated with a 68 percent increase in housing renovation within four years.

Insecurity of land holdings is not the only disincentive to build well: rent controls or other similar regulations erode a landlord's incentive to maintain buildings. The situation in Mumbai, India, where neglected buildings collapse in severe storms, killing occupants, is described in some detail. Mumbai has had rent controls and distorting taxes whose adverse effects have accumulated over decades. Buildings were restricted to being only a few stories tall, hindering agglomeration, and decaying industries occupy land that could be put to better use. Such policies also contribute to the dearth of good housing and to the poor living in unsafe shanty towns that mushroom in and around prospering cities. They have also starved cities of tax revenues, so the needed infrastructure is not built, or is built badly.

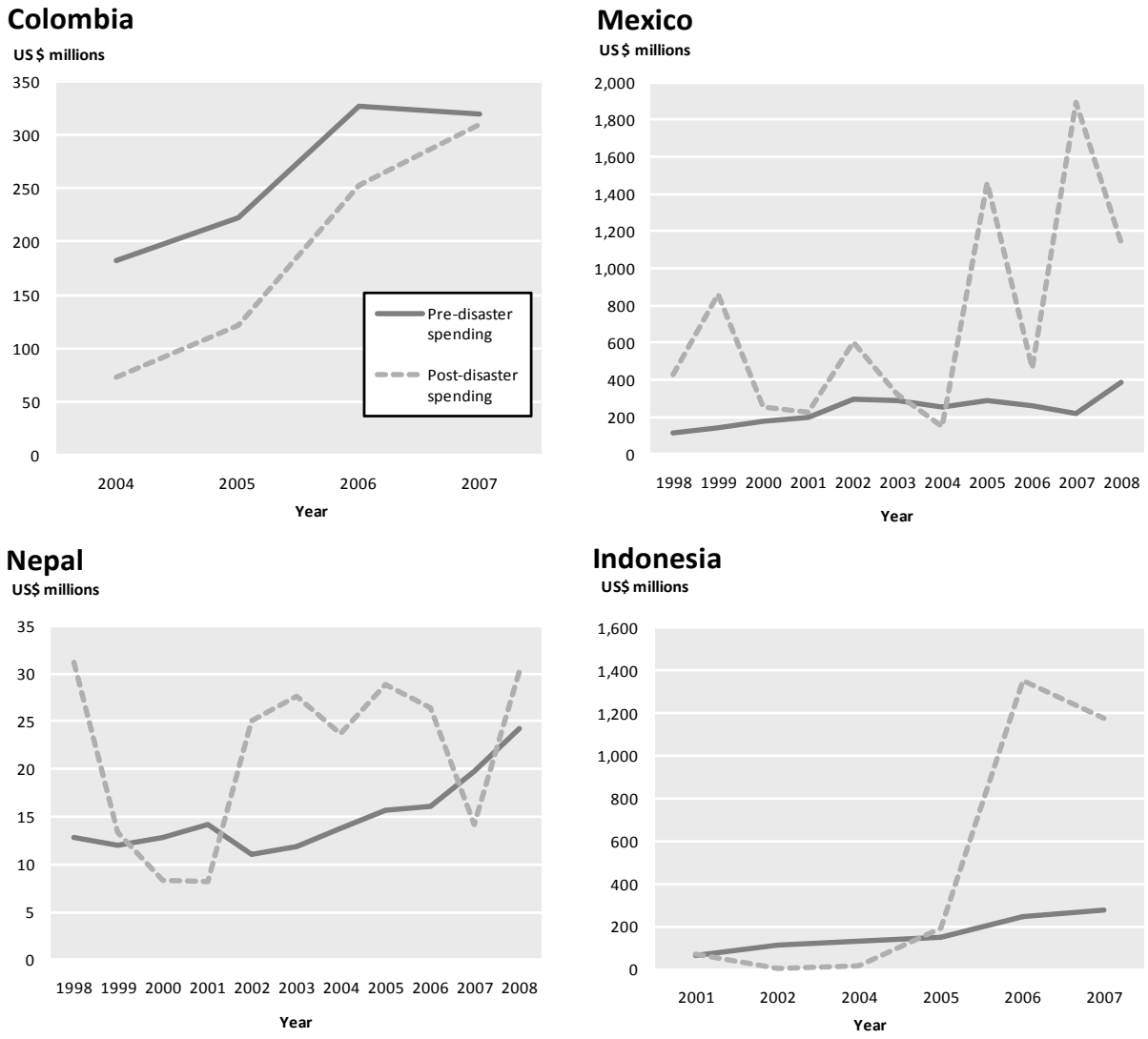
Structures are also shoddy because people do not always know the hazards they face or what it takes to build well. Detailed accounts from Italy, Pakistan, and Sri Lanka illustrate the challenge of improving building practices, the importance of information (about hazards and how to build better), and the limited role of building codes.

Calls for stronger building codes reverberate after a disaster, and stricter enforcement becomes the siren call. But there are few improvements if private owners and builders view these codes as yet another hurdle to overcome, or if officials are corrupt or complacent. Like any regulation, codes are also susceptible to capture by vested interests (California's first building code of 1933 sought to prevent the use of steel to protect the jobs of bricklayers, even though unreinforced brick structures are highly vulnerable in seismic areas). Codes work through "institutions," and are one cog in a complex system of inculcating better building practices. They are most effective when they contain accurate and accessible information about hazard risks and the properties of newer building materials, and when there are incentives to build sound structures (for example, private owners having clear title). Good building practices can be fostered even without a code, as the rebuilding after the 2005 earthquake in the remote and mountainous region of Pakistan shows.

Prevention through governments

Governments can help in effective prevention, but struggle to do so. It is difficult to measure *how much* governments spend on prevention because this is not a specific budget item. Detailed analysis in Colombia, Indonesia, Mexico, and Nepal found that prevention spending was less than post-disaster spending except in Colombia (figure 8). But this does not imply that it was "too little," for it is hard to isolate what constitutes prevention and even harder to determine adequate spending.

Figure 8. Spending on relief fluctuates more than that on prevention



Source: De la Fuente 2009.

Effective prevention measures are often embedded in other spending (in such infrastructure as an embankment), and there are indications that reversing the past neglect of maintenance (painting bridges to reduce corrosion and subsequent failure) and investing in intangibles (tallying decrepit structures) has large benefits. So, why does it not happen, and who determines government spending? Some assert that politicians are short-sighted, but competition in the market for votes, like other competition, would generally provide what the public wants. In the United States, voters favor relief spending over prevention, leading some to conclude that voters (not politicians) either are myopic or misperceive hazard risks. The findings are equally consistent with far-sighted voters being skeptical (perhaps justifiably) of politicians' ability to organize prevention effectively.

The challenge for governments is to translate spending into effective prevention, and cost-benefit analysis is a useful tool—but one that must be used with care. The benefits of prevention are understated if human lives are not valued, but attaching a value to life has enormous moral and ethical implications. Most government spending, especially on prevention, has distributional implications: a dam protects one group but may increase the flood risk of another. Cost-benefit analysis attaches implicit weights—and while these could be explicitly changed, officials lack the moral authority to decide unilaterally. Such decisions require a political consensus that countries with good institutions possess.

Cost-benefit analysis is a filter that can rank alternatives, not a scoop that can generate options. Prosperous countries have better prevention because they also have good institutions that oversee government decisions. Such oversight cannot be only through legislative bodies. And broader involvement requires the government to fully disclose what it knows and does—transparency not just about a decision but the entire process—and to encourage (not just grudgingly tolerate) dissenting views.

The report identifies three specific spending items desirable for prevention. *An early warning system* can save lives and property. There have been many advances in weather prediction technologies, but few countries have taken full advantage of that. The report outlines these technological developments and how a modest but well allocated increase in spending—and sharing real-time data internationally—would benefit countries.

Critical infrastructure that functions during and after a disaster reduces the loss of life and property. While all infrastructure must be well designed, constructed, and maintained, designating a subset as "critical" allows the government to pay special attention to it. What is critical depends on the situation and the hazard. Critical is not synonymous with the importance of some infrastructure in normal times: the choice requires informed judgment.

Environmental buffers offer protection from hazards within physical limitations. Forests and wetlands offer little protection from extreme floods when soils are already saturated. Similarly, mangrove belts a few hundred meters wide can significantly reduce the destruction from a small tsunami but not a big one. Protecting the environment is cheaper than restoring it, but knowing what to protect is hard because development involves change, and many changes are unforeseeable. But some who seek to protect the environment may have also exaggerated the benefits in cost-benefit analysis: careful analysis is important but difficult. Again, good institutions help: when more people observe—and question—what is happening, better things get done. When governments make what they know freely available and what they decide transparent, the benefits invariably follow.

Insurance and coping

People do not take prevention measures to eliminate all risks—nor can they. Insurance and other measures (borrowing, setting funds aside, remittances) "soften the blow" when disasters unfold. But these measures, even though designed for and executed in ex-post situations, also affect prevention and are examined from that perspective.

Insurance transfers risk to those willing to bear it. It clearly increases a person's choices and thus well-being, but softening the blow dilutes the incentive to prevent, unless the insurance premium reflects the risk and the prevention measures that a person undertakes. The premium must also cover the considerable costs of administration, marketing, and monitoring. Many people forgo insurance if the premia are too high, so commercial insurance develops only for some risks—and in countries where enough people want it. Parametric insurance (where the payout is specified, so that incurred damages do not have to be ascertained) reduces some of the monitoring costs. But such schemes have low penetration rates in developing countries, partly because of a lack of detailed data on the frequencies and intensities of hazards and exposed assets.

Insurance invariably draws in the government—as regulator, as provider (in many countries), or as reinsurer—inevitably adding a political dimension. This often results in attempts to lower the premia through subsidies (as with flood insurance in the United States), or, conversely, to favor insurers by keeping premia high or keeping out competition. An inappropriate premium has adverse effects that are difficult to rectify later: too low a premium encourages construction in hazard-prone areas (vacation homes in Florida).

Whether governments should buy insurance against disasters is not as clear-cut as it may seem: the alternatives are to set funds aside in reserve or to borrow so that they have funds to spend after a disaster. Many governments are already indebted, and even those with low debts may find it difficult to borrow when they most need to. While individuals are risk-averse, there are good reasons for some governments acting on their behalf to be risk-neutral. A risk-neutral entity would buy insurance only if the premium were lower than the probability times the expected loss (which leaves nothing to cover the insurer's costs). This argues governments against buying commercial insurance. But a disaster that is large relative to their economy's size (as in the Caribbean, where the main unknown is the island that gets hit) may make some governments risk-averse, and insurance could be beneficial.

The Caribbean Catastrophe Risk Insurance Facility, which pools disaster risks regionally, helps countries in such circumstances purchase insurance less expensively than otherwise. Prices that insurance firms offer may differ from prices in capital markets, and such price comparisons can produce large savings, as Mexico found when issuing catastrophe bonds. The World Bank's Catastrophe Risk Deferred Drawdown Option is a loan that disburses quickly, to provide immediate liquidity if and when the borrowing government declares an emergency.

What cannot be prevented or insured against must be borne, and a variety of coping mechanisms ("informal insurance," as distinct from market insurance) have developed over the centuries, many embedded in tradition and custom. Private individuals and groups abroad send remittances directly to those they know, and such remittances surge after a disaster, even when there is no media coverage. The funds arrive quickly to help people cope.

While remittances are routinely spent on consumer durables, some improve the quality of housing. Houses made sturdier could be considered a prevention measure, though the situation varies. In Turkey, 13 years after the 1970 Gediz earthquake, the reconstructed area was peppered with heavy, reinforced, and unsafe concrete villas—mostly paid for by the earnings of family members in Germany. Better building practices are needed to ensure safe buildings. But not all who need help receive remittances, and there are sometimes impediments to such flows that the

government could remove (controls on capital flows, dual exchange rates). Private remittances also help develop banking and money transfer facilities that strengthen an area's commercial ties with other parts of the country and the world.

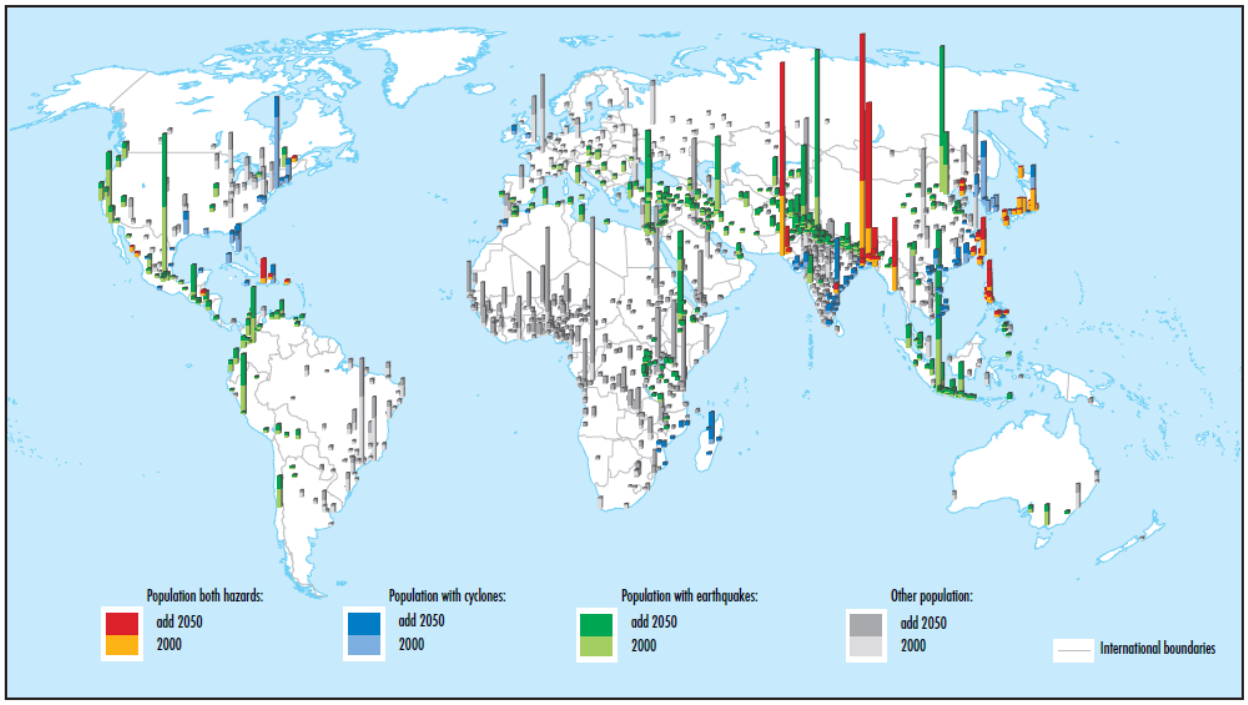
Aid also has a role in prevention, but it can be double-edged: while some aid is warranted, it can also give rise to the Samaritan's dilemma. Some observers have noted the disincentives donor programs can create—they can, for example, erase a country's incentive to provide its own safety nets. Nicaragua declined to pursue a weather indexing program after it had been priced in the global reinsurance market: it cited international assistance following Hurricane Mitch in 1998 as an indication of dependable alternatives. Some new but not very strong evidence suggests that post-disaster aid reduces prevention. It may be unfair, though, to blame only countries for neglecting prevention: Mozambique, anticipating major floods in 2002, asked donors for $2.7 million to prepare and got only half the amount, but $100 million were received in emergency assistance following the floods, with another $450 million pledged for rehabilitation and reconstruction.

Vibrant communities, however, use aid well. The main lesson for donors is to be aware of the potentially adverse effects of their actions. Governments in recipient countries can do much to prevent waste that may result from a sudden flow of uncoordinated aid or from inappropriate aid in kind.

Game-changers? Burgeoning cities, climate change, and climate-related catastrophes

That urban areas and population will grow is certain; but which cities will grow, and how fast, is less predictable. Most growing cities are in developing countries, and growth increases exposure to hazards (map 3).

Map 3. Exposure to cyclones and earthquakes in large cities rises from 680 million people in 2000 to 1.5 billion by 2050

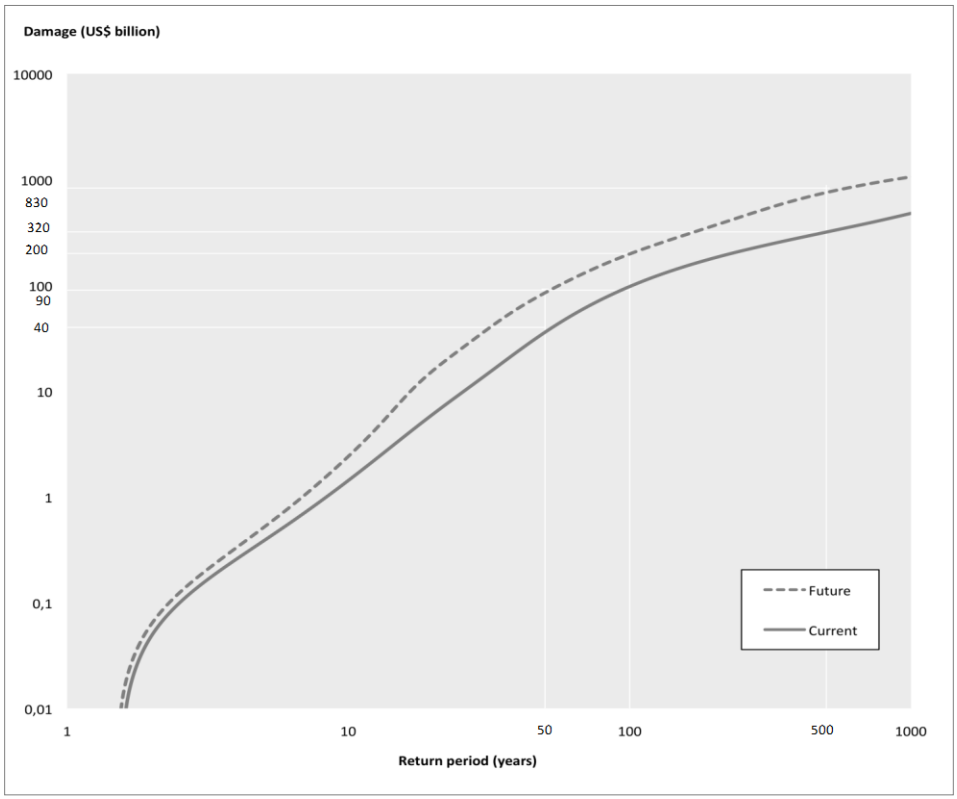


Source: Deichmann and others 2009.

The growing density of people and economic activity will change the economics of effective prevention. But greater exposure need not increase vulnerability if cities are well managed.

Climate change complicates this further. The scientific models to forecast weather do not allow confident projections at the local level, but the intensity, frequency, and distribution of hazards will change with the climate. The expected annual damage from climate-change induced tropical cyclones alone could be in the $28–68 billion range. These estimates, sensitive to various parameters and assumptions about the future, are in "expected value" terms per year. But the damages are not expected to come in a steady stream. Climate change is expected to skew the damage distribution of tropical cyclones and is likely to cause rare—but very powerful—tropical cyclones to become more common. This report finds that for the United States, destructive storms that would come every 38 to 480 years given the current climate, would come every 18 years to 89 years with future climate change. Climate change "fattens the tail" of the tropical cyclone damage distribution (figure 9). Even though very rare and damaging storms are part of today's climate, they will become more frequent in a warmer climate.

Figure 9. Climate change shortens the return period of large storms



Note: The figure shows the return period for tropical cyclones of different intensity in the United States for one specific climate model (MIROC). A $100 billion storm is estimated to happen once in a 100 years in the United States given the current climate. With a future warmed climate, it is expected to happen once in about 56 years.
Source: Mendelsohn and others 2010a.

Scientists have identified several catastrophes that a changing climate might trigger: drastic sea level rise, disruption of ocean currents, large-scale disruptions to the global ecosystem, and accelerated climate change, for example, from large releases of methane now trapped by permafrost. Catastrophic risks and costs need to be weighed differently than less severe events. Prudence in responding to catastrophic threats calls for a portfolio of measures that emphasizes learning and mid-course corrections. A broad portfolio is desirable because the potential effectiveness of individual measures is uncertain.

Cities, climate, and pending catastrophes are altering the disaster prevention landscape. While hazards will always be with us, disasters show that something has failed. But determining what has failed and deciding on the corrective measures are not always obvious. And arguing whether Hurricane Katrina or Cyclone Nargis occurred as a result of climate change detracts attention from policies that continue to misprice risk, subsidize exposure, reduce individuals' incentives to reduce risk, and promote risky behavior in the long run.

People rise out of poverty through better technology, greater market access, and more investment in activities that spill benefits from one set of economic actors to others through greater interdependence, higher productivity, and stronger institutions. Living in cities facing serious

risks of inundation is undesirable, but a failure to significantly reduce poverty would be even more undesirable. Fortunately, neither is inherently necessary. People acting individually and through responsive governments can prosper and survive. Progress requires and results in better institutions: that, after all, is the basis of sustainable development.

END