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[Home](#) > [User Resources](#) > [Sensing Our Planet](#) > Gridding the risks of natural disasters

Gridding the risks of natural disasters [1]

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When buying a new house, most people probably would not choose to live in an earthquake-prone, routinely flooded area subject to landslides and cyclones. Yet in places around the world, such as the Philippines and parts of Central America, nearly everyone considers such an area their home. To help predict, mitigate, and plan for disasters, scientists have developed a global analysis of where natural disasters occur, quantifying their human and financial impacts and identifying areas around the world with the highest natural disaster risk.

A new global data set and publication reveal the locations of the world's natural disaster hotspots.

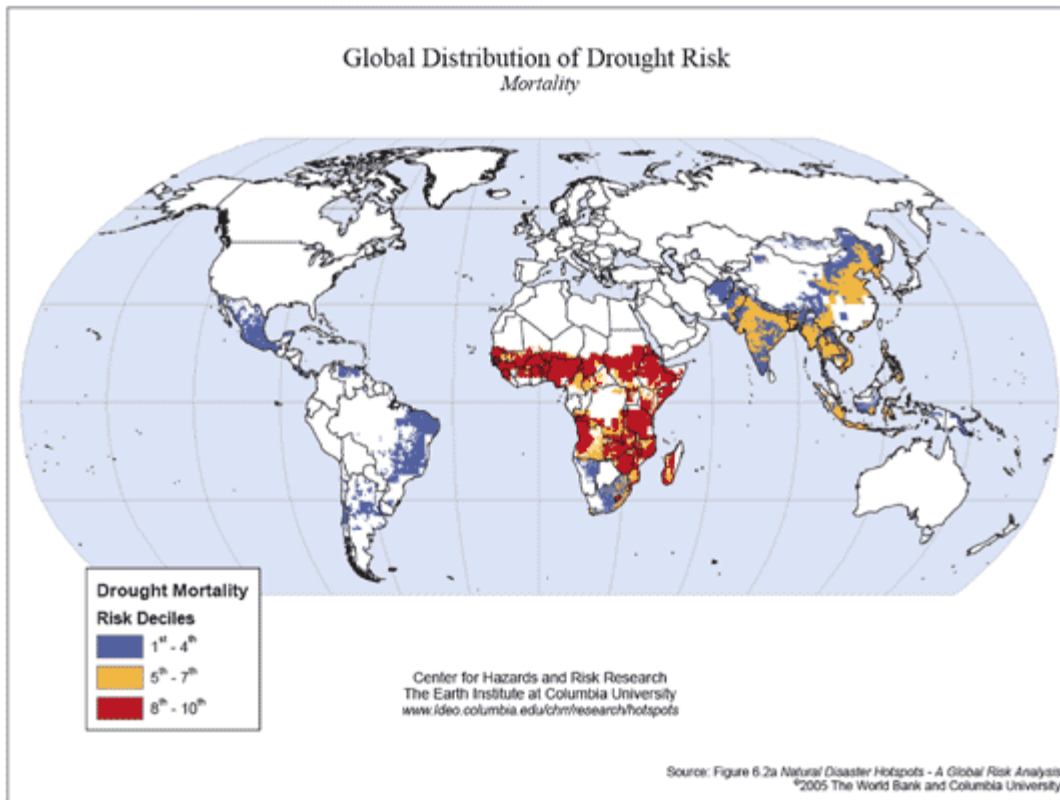
- [About the data used](#)
- [About Socioeconomic Data and Applications Center \(SEDAC\)](#) [2]

Scientist Maxx Dilley took part in a mission to develop a global picture of natural disaster risk. Dilley said, "We wanted to produce an analysis of the places in the world where disasters were most likely to occur, as well as why disasters were more likely in those places." Dilley, who now specializes in disaster and risk assessment as a policy advisor with the United Nations Development Program (UNDP) Disaster Prevention Unit, was then on a team at Columbia University, led by Robert Chen, Manager of the Socioeconomic Data and Applications Center (SEDAC), and Art Lerner-Lam, Director of the Center for Hazards and Risk Research, that collaborated with The World Bank and the ProVention Consortium on this goal. The resulting report, *Natural Disaster Hotspots: A Global Risk Analysis*, and the accompanying data set, synthesized historical data on six major natural hazards—cyclones, drought, earthquakes, floods, landslides, and volcanoes—as well as population, economic, and hazard-related mortality information. The "Hotspots" report provides the first integrated global picture of natural hazards and their impacts around the world.

Feedback

The team combined population data, provided by SEDAC, with gross domestic product (GDP) and other socioeconomic data to provide the global basis for quantifying risk. Because these data were gridded, Dilley and his colleagues could break down risk by grid cells, enabling them to analyze risk at subnational and regional levels. After masking out sparsely populated cells, they could focus on areas where natural disasters would have the greatest impact. Their analysis rated each of the remaining grid cells according to historical losses incurred from each of the six hazards, and then classified each cell's level of risk. For instance, a cell with high population that has been exposed to no hazards is rated as relatively low risk, but a cell with high concentrations of population or GDP that has been exposed to multiple hazards is rated as a hotspot.

Analyzing disaster risk in terms of grid cells also allowed their study to transcend geopolitical borders. "We get a finer sense of the risk by looking at these relatively small grid cells than we do when we're dealing with countries as the unit of analysis," said Dilley. "We start seeing regions of risk that are dictated by fault lines and tectonic plate boundaries and climatic systems that span across national boundaries."



Feedback

This map, produced as part of *Natural Disaster Hotspots: A Global Risk Analysis*, shows the global human mortality risk from drought. Areas in blue have the lowest risk, while those in red have the highest risk; white areas indicate regions where there is little or no risk. (Image above and in title graphic © 2005, The World Bank and Columbia University, *Natural Disaster Hotspots: A Global Risk Analysis*, Figure 6.2a)

Defining vulnerability

Natural Disaster Hotspots: A Global Risk Analysis is not just a compilation of new and existing data, statistics, and maps. Scientists needed to look beyond statistics to understand what makes certain communities and regions more vulnerable to natural disasters. "We faced a major challenge in how to introduce the concept of vulnerability, which is a very important element of disaster risk," Dilley said. Vulnerability assesses how a particular disaster affects a specific area, and it is a complicated combination of risk factors that accounts not just for the type and severity of disaster, but also for geography, social dynamics, land-use practices, economics, and infrastructure.

"The basic equation for identifying vulnerability is so simple, but also very subtle and very powerful," Dilley said. "If you have a collection of anything—people, buildings, or any kind of infrastructure—and a natural disaster occurs, like an earthquake, it's not only the earthquake that destroys or damages things. It's also the internal characteristics of those things, themselves, that determine the losses."





The 2001 El Salvador earthquake-induced landslide, located in a neighborhood near Santa Tecla, El Salvador, buried numerous homes under tons of earth. The Hotspots report identified El Salvador as being at high risk for landslides, earthquakes, floods, and cyclones. (Photograph by Edwin L. Harp/courtesy USGS)

An earthquake, for instance, may not damage steel-reinforced buildings on shock absorbers, but might completely destroy unreinforced masonry buildings. "We can't treat a cell in Kathmandu the same as a cell in San Francisco when we're calculating risks, because the building stock and many other things are so different. That's where the concept of vulnerability became necessary in order to come up with the results," Dilley said. While both areas are earthquake-prone, Kathmandu's masonry buildings are more vulnerable than the better-engineered buildings in San Francisco.

Feedback

Governments, aid organizations, and funding agencies are increasingly focused on quantifying vulnerability because it can help them identify in advance which areas are at higher risk than others. Margaret Arnold, the senior program officer on The World Bank's Hazard Risk Management Team, is not only one of the co-authors of the Hotspots report, but is also helping incorporate the results into various country development plans.

"We've taken the lists of the top twenty or so hotspots, and then compared it to our pipeline of Country Assistance Strategies," she said. Developed jointly by the individual government and The World Bank, a Country Assistance Strategy (CAS) lays out the priorities for socioeconomic development and poverty reduction over a certain period and determines the types of projects that The World Bank funds. "Essentially, if a certain topic isn't a priority in the CAS, then it may not appear in the portfolio of projects that happen on the ground," Arnold said.

Results from the Hotspots report are increasingly incorporated into CAS documents that are up for renewal, facilitating the integration of disaster risk considerations into development investments. "Our aim is to have both World Bank staff and our clients—our borrowing country governments—have a more proactive and preventive approach to disaster, so that we're not always just reacting and rebuilding," Arnold said.

For example, some countries, such as Bangladesh, may acknowledge high flood risk in their CAS, but not include projects designed to mitigate that risk. The Hotspots report provides The World Bank with hard evidence of a country's risk factors, making it easier to demonstrate that a particular country needs to reduce its vulnerability. "When you show countries a science-based approach, it helps convince them to invest in reducing their risk," said Arnold. "It's an awareness-raising tool. Once countries become aware of the impacts that disaster can have on long-term socio-economic growth, they can make disaster-risk reduction a development priority."

The Independent Evaluation Group (IEG) at The World Bank recently recognized the value of this approach, and used the Hotspots analysis extensively in a major review of The World Bank's record of natural disaster-related assistance. The IEG also gave the Hotspots team a "Good Practice" award for showing "demonstrated impact/results." World Bank President Paul Wolfowitz gave the award to members of the team in a ceremony in Washington, D.C., in May 2006.

In his role at the United Nations Development Program Disaster Prevention Unit, Dilley is also relying on the Hotspots report results to aid disaster-prone countries. "We help countries identify the risk factors that lead to recurring disasters and then work to establish programs that reduce and transfer those risks," he said. "Now that we have information about which countries are at risk, we have a motivation to try to do something about it."



Feedback

Boats transport World Food Programme high-energy biscuits to flood victims in Bangladesh. Organizations distributing disaster aid often grapple with destroyed roads, buildings, and basic communication channels. The World Bank's Country Assistance Strategies can help regions plan according to their disaster risk factors, and encourage countries to invest in infrastructure that will withstand commonly occurring natural disasters. (Courtesy World Food Programme)

Reducing and transferring risk

Risk transfer is one strategy that countries can use to limit their natural disaster liability. Risk transfer works like car insurance. After a car accident, the car owner is not burdened with the entire expense of replacing the car, because the insurance company pays for a portion of the loss. Similarly, a pilot program in Ethiopia lets farmers obtain a form of weather insurance. "Farmers can buy something like a lottery ticket prior to the season, and if the rainfall is below a certain threshold, they get paid back a certain amount when they cash that ticket in," Dilley said. "Rather than the people who are at risk suffering all the losses when a disaster occurs, they can transfer some of that risk away to somebody else."





This maize, severely stunted by drought in Southern Province, Zambia, should be the height of the farmer's shoulders. The farmer indicated that he would not harvest any maize from this field. Subsidized drought insurance would help protect farmers during years with low precipitation. (Photograph by F. Sands/courtesy USAID)

Insurance helps transfer the risk to a larger, often global, market, which can absorb small losses more easily than individual farmers can. In addition, when drought does occur, farmers with insurance can rely on timely payouts that would prevent them from having to sell their assets. This immediate post-disaster assistance would leave them with more resources with which to begin the next planting season.

Dilley added that risk transfer becomes more viable when countries reduce their risk. "But that depends on the hazard and on what kind of activity or infrastructure exists," he said. "Reducing risk associated with earthquakes is very different from reducing risk associated with drought." For example, reducing risk in countries like drought-stricken Ethiopia is extremely difficult. Even in a good year, Ethiopian farmers may make only a small profit, and then rainfall over the following years may be so low that they lose what little they had. "The risks of farming there are so high, and the upside so low; there's almost nothing to be gained. In these kinds of places, we need to come up with measures to reduce their risk, and as a complement to that, institute some kind of insurance for when they do lose their crops," Dilley said.

Because many of the people most frequently affected by natural disasters are poor, organizations must not only develop innovative insurance programs, but work to reduce premium costs as well. To help finance the weather insurance program in Ethiopia, the World Food Programme sought donors to help subsidize the premiums and make insurance more accessible to poor farmers.

Feedback

Another risk reduction strategy is to replace buildings and homes with structures designed to withstand the natural hazards that the area is historically known to experience. "Very often, the period immediately after a disaster is your best window of opportunity for doing something about the next disaster," Dilley said. Being aware of the hazard risk helps inform which building codes need to be improved and which construction methods will help prevent similar structural failure when a similar disaster happens in the future.

Dynamic analysis and local perspective

While *Natural Disaster Hotspots: A Global Risk Analysis* is already a valuable tool for increasing awareness about disaster risks, Dilley and Arnold believe that this is just the beginning. Arnold said, "For The World Bank, this is the really critical tool for making decisions on development priorities. It has been useful so far, and we want to continue to develop it and make it an even more useful tool.



After the 2004 Southeast Asia tsunami, aid organizations provided clothing to help disaster victims like these children in Sri Lanka. Disaster recovery involves not only rebuilding, but finding

ways to provide essential resources to the population until roads and distribution facilities are restored. The Hotspots report indicates that the nation of Sri Lanka is at extremely high risk for floods and flood-related mortalities. (Photograph by Dr. Graeme Peel/courtesy AusAID)

The original hotspots data are now available through SEDAC, and selected data sets are being put online through interactive mapping servers. But the team is also planning to make current data more easily accessible. "Right now, the Hotspots report is a static look at the vulnerability picture," Arnold said. "We'd like to create a dynamic picture, because things like demographic changes, climate change, and environmental degradation will change that picture over time." A dynamic analysis incorporating these changes may help reveal future hotspots or changes in disaster-related impacts. In 2006, the team also published Natural Disaster Hotspots Case Studies, which addresses specific hazards and specific locations.

Dilley indicated that in a few years, the team plans to release a new analysis that will incorporate updated information and provide more national-level detail. Although a global perspective is insightful, much of the disaster aid is distributed on a national basis, making it important to understand specific needs within individual countries. "We want to get a more detailed view about what the national and subnational vulnerabilities and risks are and why," Dilley said. "We'll try to work with governments and universities to obtain local risk information. We are also working closely with SEDAC to incorporate some of their new data on population, urban areas, poverty, and infrastructure."

Arnold added that the subnational data is important when rebuilding infrastructure. "For example, it's one thing to say that Indonesia is very vulnerable to natural disasters. But Indonesia is a huge country and we need to be able to drill down and decide where to put hospitals and determine what construction standards we need to use," Arnold said.

Dilley and Arnold plan to continue building on the Hotspots work for more dynamic risk mapping and locally defined strategies. But they both believe that the global perspective presented in their work so far is a big step forward. The Hotspots report provided an unprecedented look at not only the distribution of certain hazards, but at the magnitude of their impacts. "I knew that floods and droughts were major hazards, but I didn't realize how flood-prone a lot of Asia really is," Dilley said. "I was also surprised by the geographic extent of some of the flooding. The report gave me a fresh look at things. I'm still looking at the Hotspot report maps. And I'm still learning from them."

Feedback

References

Arnold, M., R. S. Chen, U. Deichmann, M. Dilley, A. L. Lerner-Lam, R. E. Pullen, and Z. Trohanis. 2006. *Natural disaster hotspots case studies* [3]. Washington, D.C.: World Bank Publications. Accessed July 6, 2006.

Dilley, M., R. S. Chen, U. Deichmann, A. L. Lerner-Lam, and M. Arnold. 2005. *Natural disaster hotspots: A global risk analysis* [4]. Washington, D.C.: World Bank Publications. Accessed March 26, 2006.

Related Links

- [NASA Socioeconomic Data and Applications Center \(SEDAC\)](#) [5]
- [Center for Hazards and Risk Research at Columbia University](#) [6]
- [The World Bank](#) [7]
- [United Nations Development Programme](#) [8]

| About the remote sensing data used | |
|------------------------------------|---|
| Data sets | Gridded Population of the World [9] |
| Grid resolution | 2.5 arc-minutes |
| Maps | Regional |
| Parameter | Population |
| Data center | NASA Socioeconomic Data and Applications Center (SEDAC) [2] |

Science
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- [2] <https://earthdata.nasa.gov/data/data-centers/sedac>
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- [5] <http://sedac.ciesin.columbia.edu/>
- [6] <http://www.ldeo.columbia.edu/chrr/index.html>
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- [8] <http://www.undp.org/bcpr/disred/>
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Feedback