U.S. Investment

Rising vulnerability to floods risks devastating property losses in U.S. cities

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In coastal cities around the world, flood-related losses are increasing. American cities are among the most vulnerable, with coastal assets having a relatively high overall value and relatively low levels of protection compared to other wealthy countries in Europe and Asia. In recent decades, population growth and real estate development in low-lying coastal areas have raised the overall value of assets exposed, driving the increase in losses. Current land-use policy and building practices all but guarantee that the trend will continue.

Climate change exacerbates flood losses, as global sea-level rise makes flooding events more destructive. Unless cities adapt by improving flood defense infrastructure, average annual flood losses in the U.S. could reach staggering levels—more than $200 billion annually by 2050. Many of the most vulnerable U.S. cities have formed or begun to implement adaptation plans, so losses of this magnitude can be avoided.

Flood losses will still increase, however. Defenses reduce the probability of flooding but still can be breached or overtopped during high-impact weather events. Higher sea levels will make these floods more destructive, and ongoing coastal development will have raised the value of the property exposed. Even if improved defenses offset sea-level rise and maintain current flood probability, average annual losses could leap above $9 billion by 2050.

Owners of commercial real estate (CRE) will bear a significant share of future flood losses. By 2050, U.S. losses from damage to CRE are likely to average more than $1 billion per year (in 2010 dollars). Owners of apartment buildings could face average annual losses above $190 million. Market disruption following extreme flooding events will likely cost CRE owners additional hundreds of millions of dollars.

Investors can account for projected losses when evaluating potential investments. Property owners can retrofit properties and increase insurance. Redevelopments of existing properties can factor in future flood risks. Such steps come at a significant cost, but the cost of inaction could be far greater.

AMERICAN COASTAL CITIES ARE PARTICULARLY VULNERABLE TO FLOODING

Across the 17 largest coastal metropolitan areas in the U.S., more than $1 trillion of assets were exposed to potential losses from catastrophic 100-year floods[1] as of 2005.

A team led by Stephane Hallegatte of the World Bank translated such exposure into an estimate of average annual losses—the standard metric for disaster risk management planning—for each of 136 global cities, taking into account infrastructure-based adaptation (for example, dykes and sea walls) and the vulnerability of populations and assets.[2] For the 17 U.S. coastal metros, Hallegatte and his team estimated a combined average annual loss of nearly $2.8 billion, even with a generous assessment of the protection provided by existing defense measures. The average annual loss is the expected loss *per year*, averaged over many years.

From a global perspective, American cities were among the most vulnerable to coastal flooding, due to their relatively high total asset value located in flood zones and their relatively low levels of protection compared to other wealthy countries in Europe and Asia. The study found six U.S. metros to rank in the global top 20 for total asset value exposed to a 100-year flood event; eight U.S. cities ranked in the global top 20 for average annual losses. As such, the U.S. is over-represented in the world's top tiers for exposure and losses. It accounts for 13% of the 136 largest coastal cities globally, but 30% of the top-20 for 100-year exposure and 40% of the top-20 for average annual losses.

Figure 1: U.S. Cities Ranked by Asset Values Exposed to 100-Year Floods, as of 2005

	Metropolitan Area	100-Year Flood Exposure ($ Millions)
1	**Miami***	**366,421**
2	**New York-Newark***	**236,530**
3	**New Orleans***	**143,963**
4	**Virginia Beach***	**61,507**
5	**Boston***	**55,445**
6	**Tampa-St. Petersburg***	**49,593**
7	Philadelphia	22,132
8	Los Angeles-Long Beach Santa Ana	15,926
9	San Francisco-Oakland	15,180
10	Baltimore	14,042
11	Houston	12,954
12	Providence	7,936
13	Washington, D.C.	5,478
14	Seattle	4,549
15	Portland	1,668
16	San Jose	1,256
17	San Diego	609
	Grand Total	**1,015,191**

* Present in the global top 20

Source: Hallegatte, et al., 2013.

[1] A probabilistic term, "100-year flood" describes a flood level that has a 1% chance of occurring in a single year.
[2] Hallegatte, S., Green, C., Nicholls, R., & Corfee-Morlot, J. (2013). Future flood losses in major coastal cities. Nature Climate Change, 3, 802-806.

Three U.S. cities stood out as being particularly vulnerable to coastal flooding. Miami, New York and New Orleans alone accounted for 74% of the U.S. asset value exposure, and 65% of the total U.S. average losses, as of 2005. These three cities also claimed 31% of the average annual losses globally. Only Guangzhou, China, had a higher average loss.

The three metros form the top three in both lists. As of 2005, the Miami-Fort Lauderdale-West Palm Beach MSA had $366 billion at risk and annual average losses of $672 million. New York-Newark followed with nearly $237 billion at risk and $628 million in annual average losses. New Orleans' exposure was nearly $144 billion and its losses were $507 million.

New Orleans' vulnerability has since been reduced by post-Hurricane Katrina investments, and is likely to be further reduced.[3]

Figure 2: U.S. Cities ranked by Average Annual Losses due to Floods, as of 2005

	Metropolitan Area	Mean Annual Loss ($ Millions)
1	**Miami***	**672**
2	**New York-Newark***	**628**
3	**New Orleans***	**507**
4	**Virginia Beach***	**244**
5	**Boston***	**237**
6	**Tampa-St. Petersburg***	**89**
7	Philadelphia	**89**
8	Los Angeles-Long Beach Santa Ana	**76**
9	San Francisco-Oakland	60
10	Baltimore	48
11	Houston	38
12	Providence	38
13	Washington, D.C.	27
14	Seattle	24
15	Portland	4
16	San Jose	1
17	San Diego	1
	Grand Total	**2,781**

* Present in the global top 20

Source: Hallegatte, et al., 2013.

FLOOD LOSSES WILL INCREASE

Population growth, coastal development, climate change and human-induced subsidence are increasing the flood exposure and average annual flood losses of coastal cities worldwide. Across the 17 U.S. cities studied, population growth and development alone could account for average annual flood losses tripling or even quintupling by 2050, according to forecasts[4] by Hallegatte and his colleagues. Even with existing flood defense infrastructure performing at its potential, average annual losses in these metros could rise from 2005's $2.8 billion to $8.7 billion by 2050, simply on the basis of coastal development putting greater

[3] Link, L. (2010). The anatomy of a disaster, an overview of Hurricane Katrina and New Orleans. Ocean Engineering, 37, 4-12.
[4] This particular scenario holding sea levels at current levels.

asset values at risk. Under the scenario in which flood defenses provide minimal protection, average annual losses could increase to $14.7 billion.

By way of comparison, Hurricane Jeanne, the 15th-costliest hurricane in U.S. history, inflicted $8.1 billion in damages,[5] and Hurricane Charley, the 6th-costliest hurricane in U.S. history, inflicted $15.8 billion in damages.[6] By 2050, then, the U.S. could suffer average losses roughly equivalent to (optimistically) a Jeanne-magnitude event or (pessimistically) a Charley-magnitude event every year. Again, these estimates account for socio-economic changes only, and do not consider the impact of global sea-level rise and human-induced subsidence.

Sea-level rise raises these risk estimates via the amplifying effect it has on storm surge. Storm surge is a local rise in sea level that accompanies a hurricane or other intense storm; its height is the difference between the observed sea surface level during the storm and the normal tide level that would otherwise be present. Accompanied by large and destructive ocean waves, its effects are typically felt on coastal stretches of ten miles or less, depending on shoreline characteristics.[7]

While sea-level rise is expected to be gradual—perhaps two to five feet by the end of the century—its amplifying effect on storm surge could result in more frequent and severe flooding events within just a few decades. According to research by Climate Central, widespread areas along the U.S. coasts have a one-in-two or better chance of seeing storm surges reaching at least 4 feet above average local high tide by 2030, and 5 feet above average local high tide by 2050.[8]

Two U.S. cities, New Orleans and Houston, are subject to human-induced subsidence as well. Natural uplift and subsidence in small magnitudes is almost universal, with negligible effects on flood risk. However, some locations—cities built on deltas, in particular—are susceptible to significant human-induced subsidence due to groundwater withdrawal and drainage. Subsidence can be rapid, as much as 30 cm per year, and large, totaling more than 13 meters in extreme cases.[9] In Houston, nearly 3 meters of coastal subsidence during the 20th century increased the city's frequency of flooding and resulted in billions of dollars in damage.[10]

To gauge the extent to which sea-level rise and subsidence might exacerbate flood risk in coming decades, Hallegatte and his team forecasted average annual losses in 2050 under two scenarios. In one scenario, no adaptation is undertaken to reduce the probability of floods. In the other, cities take adaptive measures that are able to maintain the present probability of flooding. In both scenarios, the global average sea level increases by 20 cm (an optimistic figure, according to many climate change scientists), while local sea levels increase by 40 cm in cities susceptible to subsidence. Figure 3 shows U.S. coastal cities' average annual losses in 2050 under these two scenarios and the previously described scenario that includes growth in population and flood-exposed assets but no sea-level rise, adaptive measures or subsidence.

[5] Jeanne and Charley hit South Florida in 2004, but damage estimates are quoted here in 2010 dollars.
[6] Blake, E., & Gibney, E. (2011). NOAA Technical Memorandum NWS NHC-6: The deadliest, costliest, and most intense United States tropical cyclones from 1851 to 2010 (and other frequently requested hurricane facts). Miami, Florida: National Weather Service, National Hurricane Center.
[7] Ruvin, H., Murley, J., Enfield, D., Fain, S., Fair, T., Gonzalez, J., & Milian, A. (2014). Miami-Dade Sea Level Rise Task Force Report and Recommendations. Miami-Dade Sea Level Rise Task Force.
[8] Strauss, B., Tebaldi, C., & Zlemlinski, R. (2012) Surging Seas: Sea Level Rise, Storms & Global Warming's Threat to the US Coast. Climate Central Report.
[9] Ingebritsen, S., & Galloway, D. (2014). Coastal subsidence and relative sea level rise. Environ. Res. Lett. Environmental Research Letters, 091002-091002.
[10] Galloway, D., Coplin, L., & Ingebritsen, S. (2003). Effects of Land Subsidence in the Greater Houston Area. Managing Urban Water Supply Water Science and Technology Library, 187-203.

Figure 3: Average Annual Losses due to Floods in 2050 ($ Millions)

Metropolitan Area	Socio-Economic Change Only	Socio-Economic Change, Sea-level Rise* and Subsidence	
		No Adaptation	Adaptation that Maintains Current Flood Probability
Miami	2,099	7,340	2,549
New York-Newark	1,960	7,914	2,056
New Orleans (S)	1,583	161,141	1,864
Tampa-St Petersburg	763	2,997	859
Boston	741	5,557	793
Philadelphia	279	1,017	294
Virginia Beach	278	1,520	303
Baltimore	238	1,178	271
Los Angeles-Long Beach Santa Ana	188	9,427	203
San Francisco-Oakland	149	1,703	168
Houston (S)	119	6,088	190
Providence	118	525	127
Seattle	85	545	87
Washington, D.C.	74	1,045	82
San Diego	12	410	13
Portland	3	114	3
San Jose	2	11	2
Grand Total	**8,689**	**208,532**	**9,862**

* 20 cm of sea-level rise is assumed.
"S" indicates that the city is prone to significant subsidence. 40 cm of sea-level rise is assumed.

Source: Hallegatte, et al., 2013.

With no adaptive measures taken, the projected increase in losses by 2050 is huge, with aggregate losses in the U.S. increasing to more than $200 billion annually. That's roughly equivalent to losses from two Hurricane Katrina-magnitude events each year. In the absence of adaptation, the impact from sea-level rise and subsidence is much larger than the impact of socio-economic change. Fortunately, such measures are already planned or currently underway in a number of cities, so some of these numbers are already destined to drop. The figures do demonstrate the need for adaptation, however, as the costs of inaction are catastrophic.

Unfortunately, even if U.S. cities improve their flood defenses to maintain the current probability of flooding, flood losses in the U.S. will likely increase. If the probability of coastal flooding is held unchanged by upgraded coastal defense infrastructure, average annual losses in the U.S. could still increase by a factor of 3.5 or more versus 2005, reaching $9.9 billion per year. That is roughly equivalent to one Hurricane Francis (the 12th-costliest in U.S. history) each year.

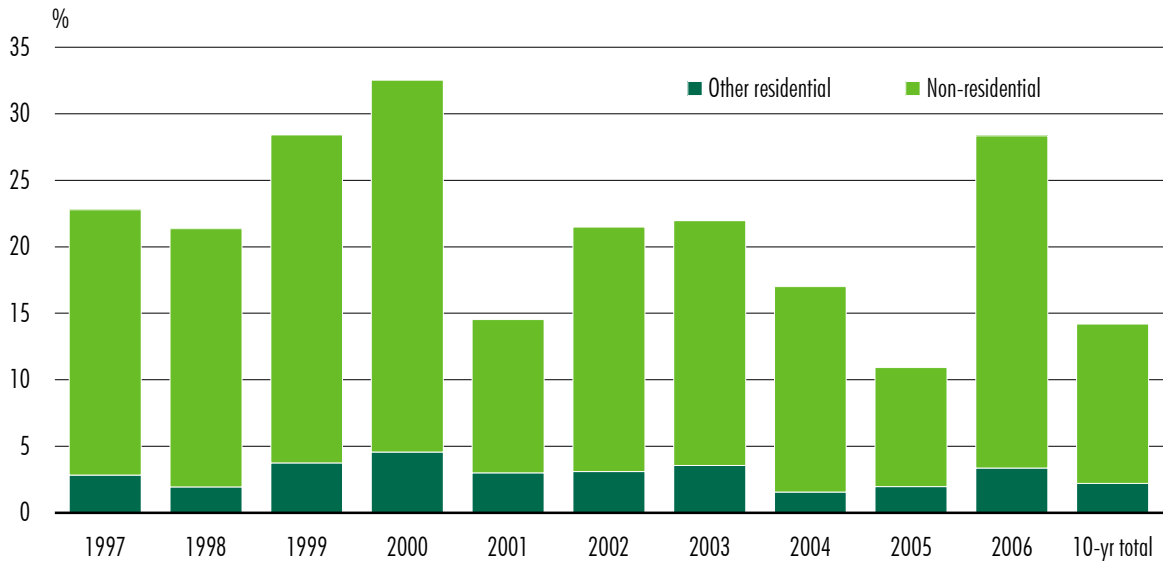
Building flood defenses does not eliminate risk. Assets in the flood plain may still be damaged in the event that protective structures are breached or overtopped by especially high waters during powerful storms. Even if adaptive investments totaling many billions of dollars reduce the probability of floods, losses will increase as sea-level rise and coastal subsidence increase the damage floods cause when they do occur, and as coastal development puts more assets, and more valuable assets, in harm's way. If flood protection is increased, coastal cities will become more dependent on flood defenses, but also more vulnerable when those defenses fail.

IMPLICATIONS FOR COMMERCIAL REAL ESTATE

A rough approximation of commercial real estate's share of future losses can be estimated using data from the National Flood Insurance Program (NFIP), which provides the overwhelming majority of flood insurance in the U.S. Policies under the NFIP insure buildings categorized into five different occupancy types: single-family residential, two- to four-unit residential, residential condominium, other residential, and non-residential. "Other residential" buildings are residential properties containing more than four units, excluding condominiums.[11] "Non-residential" buildings are commercial buildings or mixed-use buildings that do not qualify as residential. During the 10 years from 1997 to 2006, the "other residential" and "non-residential" occupancy types accounted for 14% of the loss dollars paid by the NFIP (see Figure 4).[12] Assuming the share of losses the NFIP paid to these occupancy types roughly reflects the share of total flood losses that commercial property owners suffer in the future, property owners will suffer average annual losses in excess of $1.2 billion by 2050, according to even the most conservative projection discussed above.

Apartment buildings are especially vulnerable to coastal flooding, due to a decades-long trend of residential development along the coast in major metropolitan areas. By themselves, "other residential" policies accounted for 2.2% of NFIP losses from 1997 to 2006. Using this occupancy type as a proxy for apartment buildings, a 2.2% share of total future flood losses suggests that owners of apartment buildings in coastal U.S. cities will be exposed to average annual losses of at least $192 million by 2050.

Figure 4: Percentage of NFIP Losses Attributable to "Other Residential" and "Non-Residential" Occupancy Types*, 1997-2006



* "Other residential" buildings are residential properties containing more than four units, excluding condominiums. "Non-residential" buildings are commercial buildings or mixed-use buildings that do not qualify as a residential.

Source: CBRE Research, U.S. Government Accountability Office, NFIP, 2008.

[11] "Other residential" properties are predominantly apartment buildings, but the category also includes dormitories, assisted-living facilities and extended-stay (more than six months) hotels.

[12] National Flood Insurance Program; financial challenges underscore need for improved oversight of mitigation programs and key contracts: Report to the Ranking Member, Committee on Banking, Housing, and Urban Affairs, U.S. Senate. (2008). Washington, D.C.: U.S. Govt. Accountability Office.

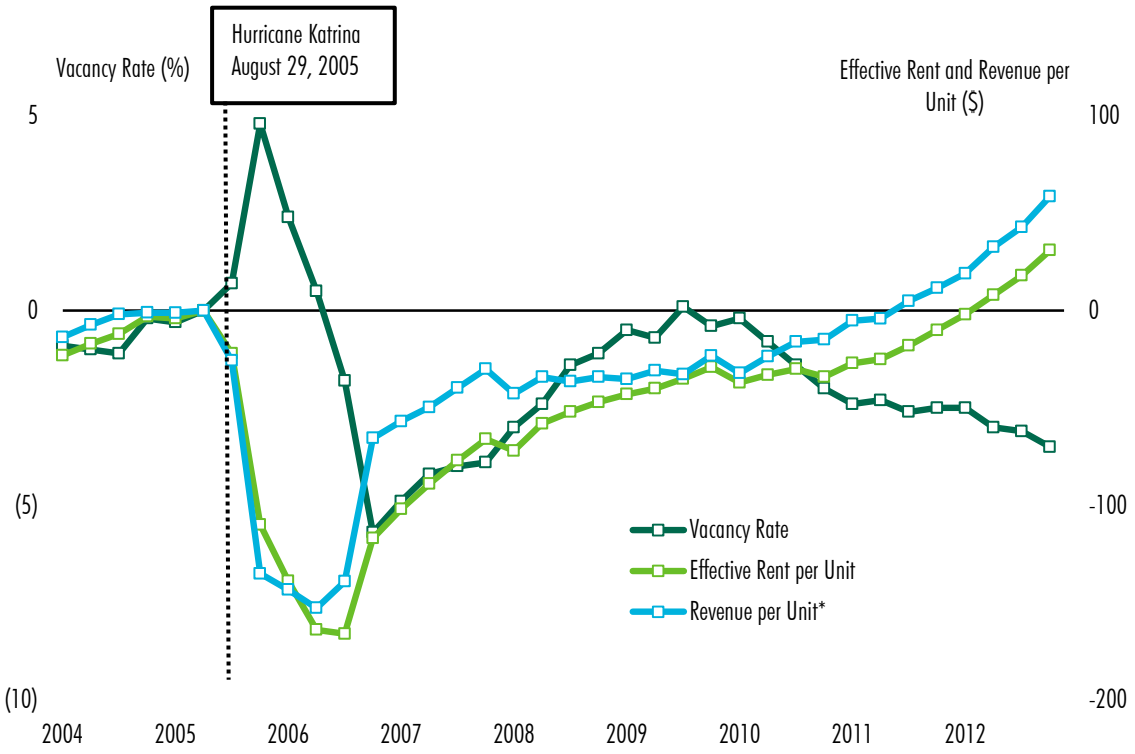
DISRUPTIONS TO REAL ESTATE MARKETS: LESSONS FROM KATRINA

In addition to property damage, highly destructive flooding events can cause long-lasting disruption to metropolitan populations, economies and social structures, significantly complicating recovery and redevelopment. Such disruption can affect commercial real estate space markets severely, compounding losses incurred due to physical damage alone.

Consider Hurricane Katrina's impact on the New Orleans apartment market. The extensive destruction caused by flooding turned the evacuation into a prolonged (and in many cases permanent) displacement for thousands of residents, and the resulting drop in apartment demand cost property owners hundreds of millions of dollars.

Figure 5 illustrates the storm's impact on the apartment market. Following the August, 2005 storm, demand for apartments in New Orleans declined precipitously. Net absorption for Q4 2005 was -1,893 units—by far the largest quarterly decline in occupied apartment units ever observed in the city.[13] The decline in demand resulted in a 380-basis-point (bps) spike in the market-wide vacancy rate and a $61 (or 7%) decline in the average asking rent per unit in Q4 2005.

Figure 5: Hurricane Katrina's Impact on the New Orleans Apartment Market (Q2 2005 = 0)



* Revenue per unit = effective rent per unit x (1- vacancy rate).

Source: CBRE Research, CoStar, Q3 2015.

[13] The decline in New Orleans apartment occupancy during Q4 2015 was almost literally a one-in-a-million event. To be precise, one could expect a quarterly decline of this magnitude to occur 1.6 times in a million quarters. Based on quarterly observations of net absorption in New Orleans from Q1 2000 through Q2 2015, negative absorption of 1890 units represents a 4.7-standard-deviation decline in demand. Assuming quarterly net absorption is normally distributed—which is supported by the observed distribution of quarterly net absorption figures—the probability of a 1890-unit quarterly decline in occupied units is 0.00016%, or 1.6 in 1,000,000.

Concessions for a 12-month lease increased from an average of about three weeks of free rent in Q3 2005 to more than five weeks in Q4, driving an $88 (11%) quarter-over-quarter decline in average effective rent per unit and a $109 (15%) decline in the average revenue per unit.[14] Average effective rent per unit continued to decline for another three quarters, eventually hitting bottom in Q3 2006 with a cumulative loss of $166 per unit (20%) relative to the quarter preceding the storm. Average revenue per unit declined through Q2 2006, with a cumulative loss of $153 per unit (20%) from pre-storm levels.

Two quarters after the storm, displaced residents began to return to the city, causing apartment demand to spike. Those whose houses had been damaged or destroyed by the flooding sought shelter in apartments as they repaired their homes or sought new long-term accommodations in the area. Vacancy rates dropped 1,050 bps over the course of 2006 as a result, slowing the decline in average revenue per unit and helping to raise revenue in Q3 2006, one quarter before average effective rents began to recover.

Even with the 2006 increase in demand, however, it was years before average apartment rents and revenue recovered to pre-Katrina levels. Average revenue per unit returned to its pre-storm level in Q3 2011, six years after the storm; effective rents finally did the same in Q2 2012, almost seven years after the storm.

Subtracting New Orleans apartment owners' total observed revenue over the six-year recovery period (Q3 2005-Q2 2011) from what it would have been at a constant pre-Katrina (Q2 2005) level provides a rough estimate of the losses they collectively incurred ($234 million) as a result of market disruption.

CONSIDERATIONS FOR COMMERCIAL REAL ESTATE OWNERS

Commercial real estate owners can take a number of steps to reduce their exposure to future flood losses:

- Institutional investors, particularly those with investment strategies that include long-term ownership, can take local flood exposure and projected flood losses into account when allocating funds across markets and evaluating potential investments in high-risk areas.
- Owners of assets in high-risk areas can install emergency generators and sump pumps, bearing in mind that such retrofits should be scalable to address the increasing threat as sea-level rise raises the severity of flood events.
- Owners can purchase supplemental flood insurance coverage in excess of the $500,000 maximum provided by the NFIP, as well as business interruption coverage, which is not included in standard property policies and which reimburses property owners for lost profits and fixed expenses resulting from business interruptions.
- Developers and property owners considering redevelopment in high-risk areas can design properties to withstand floods that overrun current and planned flood defense infrastructure.

All of these steps come at significant cost to owners, but inaction could be far more costly. Flood defenses provided by the government are not guaranteed to prevent losses. As sea-level rise magnifies the destructive power of storm surge, the probability of a defense failure—and the potential losses in the event of a failure—increase. Furthermore, owners do not necessarily have the luxury of time. While the predictions discussed in this article are for the year 2050, a catastrophic flood could hit a major coastal city long before then. The next 100-, 500- or 1,000-year storm could strike any year. Without significant change in the attitudes, policies and laws governing coastal building practices, such an event will produce devastating property losses.

[14] Revenue per unit = average effective rent x (1-vacancy rate).

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