Flood Risk and Housing: An International Perspective

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Synopsis

Global warming is likely to increase precipitation and storminess in many parts of the world, and raise sea levels. It is also likely to distort regional weather patterns, causing monsoons to occur more intensely and in different locations. At the same time, patterns of development may increase drainage problems and cause some urban areas to be more vulnerable to subsidence. Because the costs of flood defence increase disproportionately with the height of barriers, comprehensive flood protection will not be viable in many areas. Climate migration and temporary displacement of flooded populations will pose major challenges for housing systems. Encouraging individuals to take responsibility for their own flood resilience has so far proved problematic. Planners face the difficult task of identifying and managing optimal changes to land use patterns in the light of uncertain flood risk estimates, making sense of house price signals, and providing appropriate incentives for firms and households. House prices are important because of their impact on personal and institutional financial stability and as a potential measure of welfare loss. However, decision makers need to be clear about the meaning of economic loss, and the potential pitfalls associated with employing hedonic house price analysis to estimate the impact on human wellbeing.

Keywords:

flood risk, climate change, hedonic analysis, land use planning, insurance.

Introduction

Floods are a major environmental risk. This is clear from the scale of devastation wreaked by major floods over the past decade in New Orleans, USA, in 2005, Jakarta, Indonesia, in 2007, and Pakistan in 2010. Floods currently account for half of the fatalities across the world arising from natural disasters (Fay *et al*., 2009, p.28). Many of the consequences of flooding extend beyond immediate fatalities, however, imposing major damage and disruption to housing, living conditions, infrastructure, and the local economy. Global warming will likely intensify rainfall and storminess, and raise sea levels, which, together with increasing human development on floodplains, will leave many more people and homes at risk of flooding. This article examines the reasons why flood risk is likely to be a growing factor in determining both the future demand for, and supply of, housing in many countries. We look at the impact of flood risks on house prices, insurance, mortgage lending, displacement and migration. Adoption responses through physical resilience and land planning are then considered.

Expected increase to flood risk

Global warming is likely to increase the frequency and severity of floods due to the combined effects of increased precipitation, storminess, distorted regional weather patterns (particularly changes to the severity, timing, predictability and location of monsoons), and rising sea levels.

Rising temperatures will boost the rate of evaporation from land and sea, and increase, exponentially, the water holding capacity of air. As a result, “the water cycle will intensify, leading to more severe floods and droughts” and “more energy to drive storms and hurricanes” (Stern, 2006, p. 60). Climate change is likely to cause increased rainfall intensity and variability in the Baltics, Central Asia, Caucasus, Central Europe, Kazakhstan, Southeastern Europe, Baltic Russia, Central and Volga, North Caucasus, Siberia and Far-Eastern Russia, South Siberia, Urals and West Siberia (Fay *et al*. 2009). “Intense short-term precipitation and the risk of flash flooding will rise across most of Europe” (Fay *et al*., 2009, p.41). Significant increases in flood risk are also anticipated in the US, where floods have already been one of the most common and widespread natural disasters.

Perhaps the most unpredictable source of flooding will be the “sudden shifts in regional weather patterns like the monsoons or the El Niño” (Stern, 2006, p.56) caused by rising global temperatures. Such weather volatility could have “severe consequences for water availability and flooding in tropical regions and threaten the livelihoods of billions” (Stern, 2006, p.56). In addition, sea levels will continue to rise due to thermal expansion of the oceans (expansion of water volume as sea temperatures rise). Such trends will be greatly exacerbated if Greenland and West Antarctic ice sheets melt, resulting in sea level increases of between 5m and 12m. This would threaten the livelihoods of at least 270 million people (Stern, 2006), a figure which could be considerably greater if the world’s population continues to increase. Particularly vulnerable regions are South and

East Asia, home to large coastal populations in low-lying areas, including Vietnam, Bangladesh and Southeast China. Stern (2006) warns that these regions could lose "15% of their land area (an area over three times the size of the UK)." People living on the African coasts would also be vulnerable, as would those living on small islands (*ibid*, p.77).

As sea levels rise, many urban areas will experience subsidence caused by cities using up groundwater. "Deltas are doubly damned, since any subsidence is often coupled with a lessened supply of replenishing sediment, which is often trapped upstream by irrigation, hydropower production and flood-control projects. One estimate puts 8.7m more people at risk of flooding in deltas by 2050 if sea level follows current trends" (Economist, 2010a). Pluvial flooding will add further to flood risks in many countries, exacerbated by increased runoff due to urbanisation, road building, and more intensive agricultural methods. The cost of maintaining coastal defences is likely to be prohibitive for many areas (e.g. Colman 2009), not least because flood defence costs rise disproportionately with the height of barriers (Stern, 2006, p.76). Every centimetre rise in sea levels will cause a large reduction in the total area of land that can be feasibly protected.

It should be noted, however, that predictions derived from climate models, despite their sophistication, cannot forecast with any meaningful degree of accuracy the patterns of weather in particular years or locations (due to the huge natural variation in weather over time and space, and the relatively short timescale of the historical data on which climate models are trained). Nevertheless, such models offer a plausible spectrum of climate scenarios over which there is broad scientific agreement (Royal Society, 2010). Despite attempts by governments and international organisations, there is little sign that global emissions trajectories will deviate significantly from the “business as usual” scenarios assumed in recent climate forecasts (Economist 2010a). It is therefore incumbent on governments and housing researchers to take seriously the projected increases in flood risk and develop strategies that will help communities cope with a range of climate scenarios.

Impact on Housing:

We turn now to the specific ways in which flood risk is likely to impact on housing.

1. House Prices

The most common theme in the empirical housing literature on flood risk is the impact on property prices. There are at least three reasons to be concerned about house price effects. Firstly, house prices reflect the value of collateral upon which mortgage finance is based, and the housing wealth on which many people rely for their retirement. The impacts on both individuals and institutions of falling house prices due to flood risk, particularly where the impact is not foreseen, could become a major concern. Second, house prices play a key role in sorting households into houses according to their ability to pay. The potential geographical redistribution of poor households into high flood risk areas raises issues of social justice, particularly if it is wealthier households who have played a disproportionate role in emitting the greenhouse gases that caused the inflated risks. Third, house prices can, in principal, be used to place a monetary value on the reduction in quality of life associated with a particular environmental risk (Boyle & Kiel, 2001). Hedonic analysis attempts to control for the factors which cause house prices to vary across locations, and allows researchers to estimate the amount that individuals are, on average, willing to pay in order to avoid exposure to particular risks. In offering a way of quantifying the effect on human wellbeing of flood risk, hedonic estimates could provide useful inputs to cost benefit analysis of flood intervention schemes, and to planners seeking to map out the optimal use of land under a changed climate.

The results from existing research are mixed, however, and caution is needed when interpreting the implications of a particular study. Many authors have reported that floodplain location does indeed lower house prices, but the estimated magnitude of the price discount varies considerably. For example, MacDonald *et al*. (1987) found that the price of dwellings on the floodplain in Monroe, Louisiana, were 6% to 8% lower than comparable properties outside of the floodplain. Other studies have placed the negative price impact to be 4% (Skantz and Strickland 1987, Houston, Texas data), 4.2% to 6.3% (Speyrer and Ragas, 1991, New Orleans data), and 6.2% to 7.8% (Bin et al. 2008, North Carolina data). However, other investigations have estimated the price effects to be zero (Zimmerman, 1979; Lamond, 2009), or even positive (possibly due to waterfront amenities—Morgan 2007). There is similar ambiguity in studies that estimate the price impact of a particular flood event. Harrison *et al*. (2001) and Bin & Polasky (2004) reported negative impacts on house prices, whereas Tobin and Montz (1989) estimated prices to be higher following a flood, possibly due to post-flood renovation and quality improvement. That some studies (e.g. Bin and Polasky 2004) have found evidence of price falls for properties on recognised floodplains following a flood does at least suggest that flood risks are only partially capitalised into property values.

Empirical discrepancies between house price studies are partly the result of methodological failings, notably small sample sizes, sample selection problems, failure to control for dwelling attributes and failure to establish the counterfactual (Chen *et al.* 2010). Further problems arise, however, when attempting to extrapolate from these studies to estimate the house price effects of future increases in flood risk due to climate change. Chen *et al.* (2010) argue that the potential magnitude of the flood impact on house prices may be considerably greater and more complex in a climate-changed world because of: (a) changes to the location and type of properties affected; (b) the systemic nature of the risks and costs implied by climate change to financial institutions and governments; (c) tipping points in market adjustment to extreme weather due to the dynamics of employment location effects, imperfect information and behavioural factors;[1] and (d) the intersection of spatial-spillovers arising from the proximity of multiple flood-risk hot-spots.

2. Insurance and Lending

Insurance can help limit exposure to flood risk by protecting households against the costs of home repair and refurbishment. In an efficient market, the annual cost of insurance should be equal to average annual flood damage plus insurance administration costs (Foster 1976). This means that the long run cost of annual premiums equates to the long run cost of flood damage, which in turn should be reflected in house prices. While some studies find evidence in support of this theory (MacDonald et al., 1987), others report that the price discount of

[1] Markets could be better informed in future because of widespread use of risk-based insurance premiums, media coverage and government regulation. For example, some have argued that government should require house sellers to provide potential buyers with information on flood risks (HoC, 2010, p.33).

floodplain location is less than the present value cost of future flood insurance premiums, possibly because property buyers are poorly informed about flood probabilities and tend to underestimate the risk. For example, Harrison et al. (2001) used the 1994 National Flood Insurance Reform Act (designed to increase participation in the flood insurance scheme) to show that the price discount due to floodplain location was much greater after the implementation of the Act (based on data from Alachua County, Florida). This result may suggest that mandatory insurance increases market awareness of flood risk.

Insurance is not a panacea, however. First, there is the dilemma of whether to fully price risk—i.e. charge those who live in high risk areas proportionately more for their insurance cover. If premiums do reflect risk, this raises the problem of affordability and the prospect of the most vulnerable households being the least able to ameliorate risks. If they do not, then perverse incentives can arise—e.g. to live and build houses on floodplains (consider the 133,600 new homes constructed on floodplains over the period 1996 to 2005 under the UK system of flat rate insurance premiums (Kenna, 2008)). Second, insurance may dampen the incentives for households to take measures that mitigate the impact of flooding (HoC, 2010, p.34). Third, there is the problem of systemic risk. Global warming undermines both the independence and infrequency of flood events, and hence undermines their insurability. It also raises the spectre of massive weather events that could cause devastation beyond the ability of local insurance companies to cope. Reinsurance can spread the risk still further, but this is likely to increase premiums and the prevalence of exclusions, and lead to further vulnerabilities in world financial systems.

If high risk properties become uninsurable (or the premiums prohibitive), then there will be knock-on effects for the availability of mortgage finance (lenders will be reluctant to issue loans on uninsured properties susceptible to flooding) and for house values (demand would be confined to cash buyers).

3. Displacement and Migration

Two obvious housing impacts of floods worldwide include: (1) the immediate displacement of households in the aftermath of flood events, and (2) the migration of large numbers of households due to gradual depopulation of areas that repeatedly flood. Hurricane Katrina, for example, displaced around 650,000 people from New Orleans in 2005, of which around half had not returned by August 2006, and only two thirds had returned by June 2007 (Paxson and Rouse, 2008). Floods in Kazakhstan in 2008 forced 13,000 people from their homes, with predictions that up to 250,000 could be displaced long term due to rising flood risks (Fay *et al*. 2009, p.35). The full extent of the devastation caused by the Pakistan floods of 2010 is still unknown but estimates suggest that 20 million people may have been affected, with nearly two million homes damaged or destroyed and a fifth of the country's total land mass flooded (Economist 2010b).

According to Stern (2006, p.77), between 150m and 200m people could be "permanently displaced by the middle of the century due to rising sea levels, more frequent floods, and more intense droughts." Although migration patterns are difficult to predict, it is likely that such floods will intensify the flow from "southern regions to northern regions of Europe and the USA" (Stern, 2006, p.77). Given that countries such as the UK are already taking steps to reduce in-migration, following public pressure to do so, there are major unanswered questions about who will bear the housing burden of climate migration. While there are considerable uncertainties regarding the pace and extent of future rises in flood risk, there remains huge potential for human suffering, and an unambiguous imperative for governments to have appropriate contingency plans in place to prevent housing systems being overwhelmed. Clearly, the rise in flood risk due to climate change, and the associated migration flows, could be a major source of inflated housing demand in regions that are either unaffected by climate change or have the resources to assuage the consequences.

Adaptation Challenges

1. Physical Resilience

One way of reducing the flood risk impacts of climate change is to increase the physical resilience of dwellings and neighbourhoods. The challenge for governments and planners is "How to decide whether to spend millions to protect against a flood that may never come?" (Fay *et al.*2009, p.2). For many countries, the number of areas subject to flooding will greatly exceed the resources available to provide flood defences, forcing governments to choose which areas to defend, and which to abandon. Cost Benefit Analysis offers a well established framework for such decisions, but there are very real challenges regarding how to assess the uncertain and intangible impacts on human wellbeing which may be at least as important as the more easily measured losses issued by insurance companies. Assessing the wider economic impact will also be difficult because some local economies will be considerably more resilient than others to major shocks, and some may even benefit (Kahn, 2010).

If governments are limited in their ability to provide comprehensive flood defence, a related question is how to induce households and firms to take measures that minimise their vulnerability to flood events. As with climate *mitigation* (achieving reduced CO_2 emissions), it is becoming apparent how great are the "human psychology … informational and cognitive barriers" (Fay *et al*. 2009, p.2) to climate *adaptation*. For example, despite the huge increase in research and media coverage of climate change and its environmental impacts over the past decade, Anderson *et al.* (2010) find no evidence that this has led to a corresponding change in attitudes or behaviour towards the environment in the UK. A recent review of adaptation action in the US shows "continued chronic failure to upgrade standards to more appropriate ones despite the existing information on increased likelihood of floods, droughts, and hurricanes" (Fay *et al*. 2009, p.9). Irrational responses have been explained variously as being due to people having a fundamental inability to cope with intangible risks that are perceived as global or distant in time or space (Pryce *et al*. 2011).

2. Land Planning

Cities have emerged in particular locations because of good access to water. Yet this very proximity may, for many urban areas, become their source of greatest risk. Cities face an elemental conflict between protean climatic patterns and inert human development. Dwellings, offices, roads and railways constructed now are likely to remain in place for tens, if not hundreds, of years. How can planners rise above the myopia and sluggishness that plagues individual decision making (Pryce *et al*. 2011), and design planning systems and incentives that will encourage the right sort of development in the rate places, long into the future?

First, land planning needs to have the right regulatory framework, one that discourages development that exacerbates the risks and impacts of flooding. For example, in an attempt to reduce pluvial flood risk, the UK Flood and Water Management Bill proposes that "developers should no longer have an automatic right to connect to the sewerage system. Instead, developers will need to provide sustainable urban drainage systems for most new developments." (HoC p.17). Second, planning needs to anticipate, and respond to, market signals. Planners have the difficult task of divining how changes to flood risk will shape the optimal location of firms and households in the long-term. For example, some industrial areas that are safe from flooding may, in future, be put to better use as residential areas, and so planners may have the important but challenging role of managing the transition to new land use patterns.

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Glossary

Climate Change: alteration to long-term global weather patterns. Such changes can arise from natural variations in the composition of the earth's atmosphere or from energy emitted from the sun. Man-made climate change arises from human activities that affect the amount of the sun's energy that is reflected from earth back into space.

Global Warming: the proposition that surface temperatures are rising, either because of natural causes or human activity.

Greenhouse Gases: gases (principally, water vapour and carbon dioxide, CO_2) that inhibit energy received from the sun being reflected into space. Increased emission of CO_2 over the past 150 years caused by human activity is thought to be a major cause of global warming.

Pluvial Flooding: also 'surface run-off flooding', refers to excessive volumes of water on land not normally submerged, caused by excessive rainfall and/or inadequate drainage.

Fluvial Flooding: also 'river flooding', refers to overflow of water from rivers or streams onto land which is not normally submerged.

Coastal Flooding: overflow of water from the sea onto land which is not normally submerged.

Hedonic Analysis: a statistical method that uses house price analysis to estimate the implicit price ("willingness to pay") for certain goods or services.

Flood Vulnerability: a multi-faceted concept relating to the capacity to anticipate, cope with, and recover from, the impact of a flood.

Climate Change Adaptation: "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007).

Cost Benefit Analysis: a method of assessing the pros and cons of different courses of action by placing a monetary value on each cost and benefit, taking into account the value of time, and of resources in alternative uses.