

# US flood insurance at 50 years: is the public–private partnership working?

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## Abstract

In the United States, the national framework to address flood risk is the 50-year-old National Flood Insurance Program where the government bears the risk and private insurers handle customer policies. The program bundles insurance with flood mapping, floodplain management, and mitigation in the Federal Emergency Management Agency. Despite financial shortfalls and political controversy, evidence shows that public support is sufficient to continue and reform the program. Originally intended to transfer risk from taxpayers to insurance, the program recently required a taxpayer bailout after major hurricane-induced flood losses. Affordability of premiums is a major financial concern, even while premiums are forecast to rise. The flood mapping program is key to risk assessment, but it needs much improvement. The risk pool depends on compliance with floodplain resilience controls, which work better in riverine environments than in coastal zones. There is evidence of increased private sector interest in offering flood insurance. Politics raise questions about whether the needed reforms will succeed, but promising initiatives are to base premiums on risk, emphasize improvements in flood mapping, increase the involvement of private insurers in flood insurance, and increase responsibility of the state and local governments in flood risk resilience.

*Keywords:* Flood insurance; Floodplain management; Mapping; Premiums; Risk

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## Introduction

Like other aspects of water management, flood risk involves several policy sectors and requires an interdisciplinary approach. In the United States, the national framework to address it is the National Flood Insurance Program (NFIP), which is authorized by the 1968 Flood Insurance Act (Public Law 90-448) and administered by the U.S. Federal Emergency Management Agency (FEMA). While the title suggests that the program is only about insurance, it also includes flood mapping, floodplain management, and mitigation ([U.S. Federal Emergency Management Agency, 2019a](#)). It is a public–private partnership, with the insurance risk pool based on the federal government as the guarantor, private insurers handling administration but not assuming risk, and support with mapping and resilience

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from the government. Despite much criticism, the NFIP has endured and passed its 50th anniversary in 2018. Evidence is that political support exists to retain the program, while adapting it to land development, climate change, and technological advancements, and shifting public expectations ([Americans for Smart Natural Catastrophe Policy, 2019](#)).

The NFIP has been evaluated in the past ([Aggarwal, 2006](#)), and the reauthorization process in 2017 offered new opportunities to assess results of the previous evaluation, as well as to review the effects and lessons of record floods of the past two decades. Drawing from the literature about NFIP policy and observations from the recent storms, this article provides a comprehensive picture of the program's challenges and proposals for reform. It addresses whether the design of the NFIP is the most effective overall approach for flood security in the changing US political context, and offers conclusions about flood insurance that may be useful in program reform or for similar programs.

## Background of the NFIP

As the background of the NFIP has been explained by other writers ([Michel-Kerjan, 2010](#); [Knowles & Kunreuther, 2014](#); [Horn & Brown, 2018](#)), only a brief summary is presented here. The program expired in 2017 and was continued through piecemeal reauthorizations during 2018. Reauthorization will be addressed by Congress during 2019 ([Cottle, 2017](#)). While not as large and arguably not as contentious as health insurance, the NFIP is complex and becoming more so. For perspective, the average annual flood loss payments from 2009 to 2017 (which is a period of high losses) were about \$3 billion ([Insurance Information Institute, 2019](#)), whereas US health care spending in 2017 was \$3.5 trillion, with some 34 percent covered by private insurance, 20 percent by Medicare, 17 percent by Medicaid, and 10 percent out-of-pocket ([U.S. Centers for Medicare & Medicaid Services, 2018](#)). This means that on a national basis, the scale of the flood insurance program is on the order of 0.1 percent of health insurance, but it is very significant in its chain-reaction effects in the building and mortgage industries and in providing a measure of security to some five million policy holders ([Center for Insurance Policy and Research, 2019](#)).

As shown by an 86-page chronology through 2005, many steps have been taken to evolve the NFIP to its present form ([American Institutes for Research, 2005](#)). National flood insurance was considered prior to the 1960s, but the impetus to pass the NFIP in 1968 was the escalating cost of disaster relief, especially from Hurricane Betsy in 1965. The basic idea was to de-politicize flood security with insurance to replace contentious relief packages passed by Congress. As will be discussed later, the political dimension has changed but not gone away.

As one of the 'Great Society' programs of the 1960s, the NFIP has earlier roots in federal involvement in river management. By the 1960s, it was clear that reliance only on structural flood control programs was inadequate, and the 1968 Act was to provide 'appropriate protection against the perils of flood losses' and to minimize 'exposure of property to flood losses'. Congress found that relief assistance was too costly, and the NFIP was created to provide access to flood insurance, transfer some financial risk to the federal government, and to mitigate flood risk by floodplain management standards ([Michel-Kerjan, 2010](#); [Knowles & Kunreuther, 2014](#); [Horn & Brown, 2018](#)).

The NFIP has been considered as problematic almost from the beginning. Two decades after its inception, [Schilling et al. \(1987\)](#) wrote 'The program has achieved mixed results. It has achieved some measure of success with regard to river flooding, but along the coasts it has been unsuccessful,

if not disastrous. Its subsidies encouraged the condominium and second-home construction spree of the 1970s along coastal areas.’ The program underwent a comprehensive review in the 2001–2006 period, resulting in reports about financial issues (actuarial soundness, market penetration, mandatory purchase requirement); development and environmental impacts; compliance of communities and building controls; the one-percent flood standard; program effects on costs and consequences of flooding; state roles and responsibilities; and performance measures for FEMA (Aggarwal, 2006). Now, five decades after its inception, the same issues are being discussed about the NFIP (U.S. Government Accountability Office, 2015; U.S. Congressional Budget Office, 2017; Strother, 2018).

The generic issues faced in the NFIP are not unique to the United States, as shown by the same ones being discussed in Europe (European Commission, 2013; Insurance Europe, 2013), thus indicating common problems with flood security and insurance approaches. The uniqueness of the US program is in its packaging in FEMA and in the way its four program elements are designed and operated as an integrated approach to flood risk management. As an example of comparative programs, those in the UK (Penning-Rowell *et al.*, 2014) and Canada (Sandink *et al.*, 2016) can be contrasted to show one approach focusing on private insurance markets (UK) and the other on government relief (Canada). The situation in Canada is similar in some ways to that of the United States before the 1968 Flood Act. Solutions require both public relief and some private insurance, and the mapping program is problematic (Nadarajah, 2016). Other comparable programs can be studied in the member states of the European Union (Surminski *et al.*, 2015) and in Japan (Square One Insurance Services, 2019).

### Challenges confronting the NFIP

The many challenges to the NFIP have been addressed incrementally during the program’s 50 years (U.S. Government Accountability Office, 2003, 2017; Michel-Kerjan, 2010; Dinan, 2017). Based on the number of studies, financial solvency remains its major challenge. The issues include operating expenses, repetitive losses, subsidized properties, catastrophic losses, and affordability for lower-income residents.

Payment of claims is the largest NFIP operating expense, but the program pays one-third of its premium income to financial intermediaries for underwriting, policy writing, advertising, general expenses, and commission incentives. These intermediaries bear none of the risk, which is carried by the federal government, but they face substantial challenges in marketing, underwriting, and adjusting for flood losses. Other operating expenses include administrative costs, flood studies and surveys, mitigation grants, and purchase of repetitive loss properties (Michel-Kerjan, 2010).

According to data from its website (<https://www.fema.gov/statistics-calendar-year>), from 1978 through 2017, the NFIP collected about \$60 billion in premiums and paid out about \$65 billion in loss payments. Adding program expenses placed the fund in debt, however. After Congress forgave \$16 billion in debt in 2016, the NFIP was able to pay claims for the 2017 Hurricanes Harvey and Irma. That left the debt to the Treasury at \$20.5 billion, compared to an authorized borrowing level of \$30.425 billion (Horn & Brown, 2018). While it was solvent until the large-scale flood events of 2005 during Katrina, the debt forgiven in 2016 illustrates that taxpayers are still footing the bill as a surrogate for relief.

Going forward, the U.S. Congressional Budget Office (CBO, 2017) estimated an expected annual shortfall of \$1.4 billion, or \$0.7 billion by excluding annual costs of \$0.7 billion for mapping floodplains, mitigating flood risk, and interest on previous debt. The anticipated shortfall is caused mainly

by expected losses in the coastal counties, which have three-quarters of all policies. Most premiums in those counties do not account for risk due to wave damage during storm surge (Kousky & Michel-Kerjan, 2015).

Repetitive loss properties are about one percent of insured properties, but account for 25–30 percent of claims. They were to be addressed by the 2004 Flood Insurance Reform Act (U.S. Congress, 2004) and by reforms in the Biggert-Waters Flood Insurance Reform Act of 2012 (BW12) (Kansas Department of Agriculture, 2019). However, the 2004 Act only implemented a pilot program and the later reforms of the BW12 were shelved, and these actions illustrate the political tradeoffs that have occurred to lubricate the wheels of the NFIP. Another challenge is subsidies of some properties that pre-dated flood mapping, and the NFIP is trying to reduce their number and impact on the program finances (Lee & Wessel, 2017). Increasing property owner participation in the program is also an ongoing challenge because the basis of the program is to have properties at risk insured, not to resort to government relief (Michel-Kerjan *et al.*, 2012).

As shown by the post-2000 disasters, catastrophic losses are the biggest financial challenge to the NFIP. These recent major storms led to high losses, and climate change with more destructive hurricane seasons as well as sea-level rise point to more losses in the future. Estimating these losses involve many uncertainties, which is a continuing issue for the insurance industry (Michel-Kerjan, 2010; Dinan, 2017). However, the NFIP is adapting to uncertainty, and it purchased reinsurance for the first time in 2016, with the result that was able to claim its full \$1.04 billion policy limit after Hurricane Harvey.

Affordability is an important issue with flood insurance. In 2016, two-thirds of premiums were between \$420 and \$1,330, with the median at \$520. A surcharge of \$250 is added for non-primary and non-residential properties. Premiums for primary single-family homes are generally less than one percent of household income, but the percentage could be significantly higher for some households (U.S. Congressional Budget Office, 2017). Thus, affordability of flood insurance has similar attributes to affordability of utility services; on average, it is affordable, but not to lower-income people. CBO analyzed keeping costs low for some policyholders while raising them for others, targeting subsidies to low-income policyholders, shifting costs to taxpayers, or adjusting premiums to reflect the value of insured properties. Affordability will continue to be a major issue. In a study for the NFIP, the U.S. National Research Council found that the program needed more data and modeling capacity to evaluate affordability accurately (National Academies of Sciences, Engineering, and Medicine, 2016).

Risk reduction is a continuing challenge. The floodplain management program seems to work well for riverine areas, but comprehensive building code and management reforms in growing coastal communities are difficult. The major technical challenge is to improve the accuracy of the flood maps, including outside of floodplains (National Research Council, 2009). This is a massive and continuing process; FEMA manages flood maps for about 22,000 communities across the United States and almost two-thirds of them have not been updated in 5 years. Some of the maps are much older. The Inspector General (U.S. Federal Emergency Management Agency, 2017) of the Department of Homeland Security reported that the mapping program is plagued by mismanagement and poor standards. It estimated that only 42 percent of the maps adequately identified the flood risk, according to 2017 data.

An example of the limitations of flood mapping can be seen in Harris County, Texas, which suffered large-scale disaster during Hurricane Harvey in 2017. In Harris County, some 40 percent of the flooded buildings were in areas considered to be of minimal flood hazard (Fessenden *et al.*, 2017). On average, over 25 percent of claims come from outside the identified floodplain (Varn, 2017).

In the face of the findings about an inadequate mapping program, FEMA attributed the delay to decreases in program funding (Federal Emergency Management Agency, 2017). Adequate funding is

always an issue for government programs, and if the program could be removed from political control, this problem should diminish.

With the program requiring Congressional appropriations and oversight, there is continued political uncertainty. [Strother \(2018\)](#) argued that prior to Biggert-Waters Act in 2012, the NFIP had no public and policies were made without contentious politics or competition among interest groups. Technocrats decided things and policy entrepreneurs could succeed without the political process. He thought that Biggert-Waters Act activated a public, as shown by Senators switching votes from pro-reform in 2012 to anti-reform by 21 months later. He thought that the NFIP shows how public knowledge of the need for a general reform does not ensure public support unless advocates of reform make their case. Recent indications are that, while a general public may not exist for the NFIP, political support among some interest groups is strong enough to sustain the program. While political uncertainty will continue, legal uncertainty is also a factor in flood risk management and a number of avenues for legal recourse are available to flood victims ([Vermont Department of Environmental Conservation, 2019](#)).

### Proposed reforms

As the NFIP evolved, different writers or organizations converge on the same general list of needed changes ([Michel-Kerjan & Kunreuther, 2011](#); [Akabas, 2014](#); [McShane & Wie, 2019](#)). Most of the recommended reforms are in the financial category, to include the following:

- Premiums be risk-based to inform homeowners of true exposure
- Unsubsidized rates
- Low-income protection
- Delaying establishment of a reserve fund
- Forgiveness of debt to the U.S. Treasury
- Address low uptake on policy purchase
- Address policy renewal by multiyear contracts, mandatory for high-risk areas
- Reduce catastrophe exposure by reinsurance and catastrophe bonds.

Suggested mitigation and floodplain management reforms include updating the vulnerability of buildings when policies are renewed every 5 or 10 years, re-evaluating flood hazards for hydrological and environmental changes, empowering FEMA to monitor existing and new construction in those areas, and providing multiyear home improvement loans to encourage flood-proofing.

Reforms to improve affordability include a voucher program (similar to food stamps and the Low Income Home Energy Assistance Program) or to have premiums for lower-income policyholders paid by explicit subsidies. Ultimately, unless some form of risk-based insurance at a basic level is available, the only recourse is some type of subsidy.

The mapping program has received a great deal of attention for reform. As required by the BW12 Act, FEMA established the Technical Mapping Advisory Council (TMAC) ([U.S. Government Accountability Office, 2015](#); [U.S. Federal Emergency Management Agency, 2019b](#)). TMAC has made many technical suggestions. The government-run mapping program can consider these suggestions, but implementing them may run into political and bureaucratic barriers.

Legislative initiatives through the program's history have considered the categories of reforms listed above (Federal Emergency Management Agency, 2019c). Beginning with the Flood Insurance Protection Act of 1973, flood insurance was required on loans secured by properties located in high-risk flood areas. Two decades later, the National Flood Insurance Reform Act of 1994 focused on lender compliance and developing a mitigation program. After another decade, the Flood Insurance Reform Act of 2004 created a pilot program to address repetitive losses and guidance for insurance professionals. The major Act to address reforms was the Biggert-Waters Flood Insurance Reform Act of 2012. It authorized and funded the mapping program for the first time in its own right. It also provided for transitioning from subsidized rates to actuarial rates that are reflective of risk. However, the subsequent Consolidated Appropriations Act of 2014 reversed some sections of Biggert-Waters and stopped some rate increases. This was followed by the Homeowner Flood Insurance Affordability Act of 2014, which restored grandfathering for subsidized properties, placed limits on some rate increases, and applied an annual surcharge to policyholders.

To provide an overview of the needed reforms, the U.S. Government Accountability Office (2017) prepared the diagram shown in Figure 1. It illustrates the focus on financial issues (five of six categories), whereas the category of flood resilience efforts is of high importance in overall flood risk management, but received less visibility in the illustration. The implication is that policy makers have accepted the NFIP's basic structure and will focus on tuning up its finances, but are not focused as much on reforming how well the integrated approach to flood risk management is working. This is not a criticism so much as it is an observation about the need for government to focus on budget and financial issues across program categories.

### Is the NFIP the best way to protect against flood risk?

The 50 years of experience with the NFIP and the emphasis on reforms indicate that the program will continue rather than be replaced. Going forward, the policy questions are how to package its program elements, reform it, assign roles and responsibilities, and operate it. To assess the program's packaging, it is useful to view roles and responsibilities through the lens of the phases of emergency management,

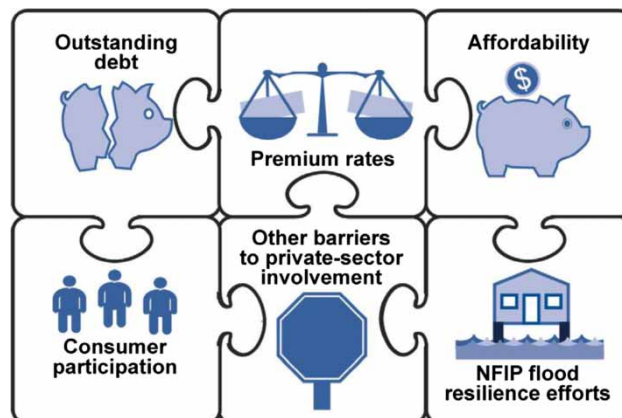


Fig. 1. Categories of NFIP reform (U.S. Government Accountability Office, 2017).

which involve planning, mitigation, response, and recovery among partners in governments, communities, and individuals. How a nation or state organizes these functions can vary, and the arrangements within FEMA have evolved through the political process to the current form. The driving force for creation of FEMA in 1978 was poor coordination of functions for emergency management, where numerous agencies were involved but integration was poor (Public Broadcasting Service, 2019). Given the challenge to integrate programs and the experience with FEMA, it makes little sense to change program structures now.

Figure 2 illustrates the phases of emergency management. Planning involves identification of threats such that actions can reduce vulnerability, as, for example, through floodplain management. Mitigation can reduce consequences from events that do occur, as in flood-proofing. Recovery involves insurance to help with losses. Mapping supports all of the activities. The NFIP does not deal in any substantial way with emergency response, as it is handled through a separate section of FEMA.

Although it seems appropriate to continue to house the program in FEMA, given its broad mission for security, managing integrated responsibilities in one agency generates conflicts, such as between the constituencies for the insurance program, the mapping program, and the programs of outreach and regulation related to local government. As the program elements mature further, it seems likely that responsibilities can be devolved to other players such that FEMA's overall role might become smaller.

Insurance is the central function of the NFIP. The need for it arises because flood events are certain to occur, but at unknown times, places, and levels of damage. People need ways to protect themselves financially from the contingencies. The NRC concluded its study with observations about how costs of damage from future riverine floods and coastal storms will be borne in three possible ways (National Academies of Sciences, Engineering, and Medicine, 2016). Individual NFIP policyholders might bear cost in the form of insurance premiums, federal taxpayers might bear costs of premium assistance, revenue shortfalls, mitigation, or post-flood disaster assistance payments, or property owners and other inhabitants might bear costs for uncompensated losses. These observations show the tradeoffs facing policy makers as they seek to reform the NFIP.

Private companies normally operate the insurance business but prior to the NFIP, the unknown risks caused them to avoid flood insurance. The hazard is known, but flood insurance is different from other types of property insurance in its complexity and nature. That is why it is normally not included in homeowner policies. The government stepped in to establish the program and create a risk pool, with

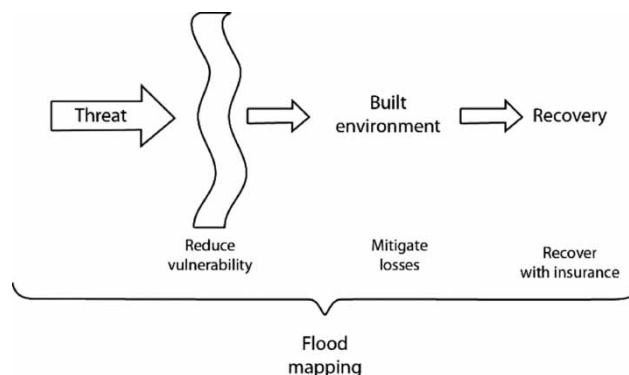


Fig. 2. Phases of emergency management and NFIP programs.

a partnership with private insurers to market and administer the policies. A government-backed risk pool is not the only way. Private sector risk pools through reinsurance provide another avenue. A non-profit risk pool approach is still another way, such as set-up in the 1990s by the California legislature ([California Earthquake Authority, 2018](#)). However, now that the program is established, the insurance industry is signaling that it wants a more active role ([National Association of Insurance Commissioners, 2017](#)). The improved capability of quantifying flood risk is the driver that changes the need for the government to assume risk and offers the possibility to transfer it to private insurers.

Flood mapping, supported by hydrologic science, is the key technology in quantifying flood risk. The complexity and importance of flood mapping makes its organization and operation candidates for scrutiny. Flood maps have evolved from the first drawings of flood boundary lines on paper maps to current technologies with much more detailed information. Eventually, the goal is to identify each structure and its flood risk separately, so that insurance premiums can be set on the basis of real risk and cross-subsidies can be eliminated.

There is economy of scale in mapping, and flood hazard mapping works best as a national level responsibility, in partnership with local governments and using contracts with private businesses. Many technical and managerial possibilities to improve mapping are available, but the political and bureaucratic aspects of mapping comprise obstacles ([U.S. Federal Emergency Management Agency, 2017](#)). For that reason, a policy study about mapping might identify new possibilities to improve the system while reducing its political content.

Organizationally, the mapping responsibility could be handled in different agencies. In the United States, it was developed within the NFIP and FEMA, but other agencies could take it on. As an example of alternatives, the [UK Environment Agency \(2019\)](#) provides flood risk information, along with other environmental information. The service enables individuals to search online for flood risk near their homes.

Flood mapping involves a mixture of geographic, land use, and economic information. Geographic mapping is the responsibility of the [U.S. Geological Survey \(2019\)](#), which has long experience with geospatial issues. Experience with land use and economic information was developed in assembling the building stock data for the HAZUS Flood Model ([U.S. Federal Emergency Management Agency, 2019d](#)). The development teams utilized a range of datasets from the U.S. Census Bureau, Dun & Bradstreet, Department of Energy, and various organizations with data on essential facilities such as hospitals, police stations, fire stations, schools, and emergency operations centers. This was an example of the power of big data, when multiple datasets are integrated to derive needed information. This use of big data to direct streams of information toward the central goal of risk calculation might be the driver of new approaches to flood mapping.

The term resilience is used to identify the overall goal of reducing vulnerability and improving the capacity to recover from flood disasters. The central features of it, floodplain management and mitigation, are logically local government issues because they involve land use and building controls. The NFIP's role in promoting floodplain management and mitigation is a cooperative activity with state governments, where FEMA it issues guidance, creates incentives, and imposes sanctions where they are needed ([Monday \*et al.\*, 2006](#)). These activities have evolved in the NFIP's Community Compliance Program, which involves activities to support state efforts to foster floodplain management, a community rating system, and periodic sanctions with decertification when required ([U.S. Federal Emergency Management Agency, 2019e](#)).

About 22,000 communities participate in the program ([U.S. Federal Emergency Management Agency, 2016](#)). Sometimes communities lose their certification for noncompliance, but they can be

re-certified. If they are decertified, no one can buy flood insurance. The last review of how well this is working was published in 2006. The indication was that the program is working as expected, but it would be complex to quantify outcomes such as how many structures have been removed and how much damage has been prevented (Monday *et al.*, 2006).

Given the need for partnerships, some aspects of the NFIP seem inevitable for political involvement, but if parts can be separated out, the political level might diminish. The political dimension is most evident in horse-trading between ways to create rate-based cross-subsidies and subsidies from taxpayers. The desire to move to a risk-based paradigm would create an economically efficient program without free riders or rent seekers. Barriers to moving to such a risk-based approach involve issues such as grandfathered properties, repetitive loss properties, and uncertainties due to inadequate flood hazard mapping.

Even after 50 years, the NFIP continues to evolve. The current organizational arrangement seems secure until reforms are further along, then transition the separate parts of the program may be transferred to logical operators. That being said, the political dimension of the program is problematic, which calls into question whether reforms can be implemented successfully in the current politicized arrangement. The proposed insurance reforms include ways to devolve responsibilities to the private sector. How this might occur would require more study. Possibilities could include a government corporation or a non-profit organization, for example.

It was a positive move to authorize and fund mapping separately from the other NFIP program components. The more that flood mapping can be separated from political influence, such as communities rejecting new maps because they raise premiums, the better chance the program has to become based more on risk and not so much on politics. Mapping could be a separate activity driven by new possibilities to use big data.

Depending on the outcomes with insurance and flood mapping, responsibilities for floodplain management and mitigation might be devolved to state governments. The important linkage between insurance and resilience requires some degree of government involvement because of the interdependencies of flood risk drivers. In other insurance scenarios, such as health insurance, the risk pools depend on how individuals mitigate their own behaviors. However, there are many signals telling them what to do, and insurers can offer checks and incentives through mechanisms such as medical checkups. With flood insurance, the risk pool depends on compliance with floodplain resilience controls and insurers lack tools to influence these.

## **Toward the future**

Fifty years ago, the United States made a policy decision to create government flood insurance, leading to the NFIP with its integrated insurance, flood mapping, and resilience activities in the FEMA. The NFIP has long been viewed as problematic, with financial insolvency and affordability as top concerns. Evidence shows that there is enough political support to continue the NFIP, while reforming it to adapt to changing conditions. Many reforms have been proposed, but with major flood events and losses of recent years they are becoming more urgent.

Financial solvency is the major challenge. Reforms proposed are to change premiums to be risk-based, eliminate implicit subsidies, increase policy uptake, and reduce risk by reinsurance and catastrophe bonds. Affordability is also an important issue, and if flood risk can be quantified better,

new possibilities to make insurance affordable might be a result. Ultimately, the major financial policy question faced by Congress is who will bear the costs of floodplain occupancy? Conceptually, there is broad agreement about the need to move to a fully risk-based program, but major barriers must be confronted, including grandfathered and repetitive loss properties and uncertainties due to inadequate flood hazard mapping.

As the NFIP moves into the future, it faces new conditions, similar to those faced by other nations. Climate variability is apparently causing more intense hurricanes, which cause more coastal zone flooding (Wuebbles *et al.*, 2017), as well as rainfall-induced flooding inland. Coastal zone changes and sea-level rise are increasing flood damage across the globe (Hinkel *et al.*, 2014). In the United States, evidence of increasing hurricane losses intensified in 2005 with Katrina (\$16.3 billion NFIP payout), then continued with Sandy in 2012 (\$8.75 billion NFIP payout), and in 2017 with Irma (\$1.03 billion NFIP payout) and Harvey (\$8.76 billion NFIP payout). Relatively few flood insurance policies were in effect in Puerto Rico, so Hurricane Maria in 2017 did not cause large NFIP payouts (Biesecker, 2017; Johnson & Hall, 2017; Insurance Information Institute, 2019).

In addition to land development, socio-economic changes include changed public expectations and philosophies of government about operating programs that could be handled by the private sector. Citizen resistance to tax bailouts favors privatization, but many resist it due to a desire for government-provided security. Increasing availability of big data and sophisticated information technologies to quantify flood risk can facilitate private insurer roles in flood insurance. These are increasing anyway, but private flood insurance is still small compared to NFIP policies (Lehmann, 2018). Now, with improved quantification of risk, the insurance community would like a bigger stake in the overall program. Technical issues must be addressed in any new arrangements, including hydrology, hydraulics, building sciences, and risk management (American Academy of Actuaries, 2017).

The improved capability to quantify flood risk is the driver that changes the need for the government to assume risk and offers the possibility to transfer it to private insurers. The National Research Council found that data and models were currently inadequate to define affordability, and a policy study about mapping might identify new possibilities to improve the system, define affordability options, and reduce the political visibility of the mapping program (National Academies of Sciences, Engineering, and Medicine, 2016). This use of big data to direct streams of information toward the central goal of risk calculation might be the driver of new approaches to flood mapping.

Flood mapping, supported by hydrologic science, is the key technology in quantifying flood risk.

The major technical challenge is to improve the accuracy of the flood maps, including outside of floodplains. A policy study about mapping might identify new possibilities to improve the system while reducing its political content. For example, in the face of the findings about an inadequate mapping program, FEMA attributed the delay to decreases in program funding.

Floodplain management and mitigation will require continued federal involvement. With flood insurance, the risk pool depends on compliance with floodplain resilience controls, but insurers lack tools to influence these. If insurance and mapping responsibilities are changed, so too might the social contract between the parties change. Depending on the outcomes with insurance and flood mapping, responsibilities for floodplain management and mitigation might be devolved to state governments.

Given the importance and difficulty in coordinating the functions of emergency management, it seems appropriate to continue to house the program in FEMA. As the program elements mature further, it seems likely that some responsibilities can be transferred to other players such that FEMA's overall

role might become smaller. How this might occur would require more study. Possibilities could include a government corporation or a non-profit organization, for example.

While 1960s policy makers thought the insurance program would remove politics from flood relief by a quasi-market system, the political dimension remains. If changes in this public–private program can reduce the political dimension, the problems should diminish. From a technical and administrative standpoint, an old slogan applies: ‘this isn’t your grandmother’s NFIP’. The more important question is, can the political system deliver the needed reforms? If it can, the NFIP could become a case study of a program started by government, but with a successful handoff of many of its functions to the private sector.

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