Chapter 4

Improving the insurability of flood risk

This chapter provides an overview of possible approaches to improving the insurability of flood and their relative effectiveness based on the experience of many countries. This includes improvements in land-use planning, investments in risk reduction at the community and household levels as well as efforts to improve understanding of flood risk and the need for financial protection. The role of premium subsidies in encouraging demand for flood insurance is also examined, including some of the challenges in eliminating such subsidies over time.

Chapter 3 outlined the general market failure in private insurance markets based on a number of factors that lead to an increase in the price of flood insurance premiums (size of expected losses, limited and correlated risk pools and uncertainty in the quantification of potential exposures) and a number of factors that reduce the willingness-to-pay for flood insurance (underestimation of risk, misunderstanding of coverage and expectation of government compensation). This chapter will provide an overview of the measures that have been put in place in countries to address these specific factors, including prevention and risk reduction measures aimed at reducing the frequency and/or severity of flood losses, improvements in the mapping of flood risk that should reduce uncertainty as well as a number of interventions aimed at supporting demand and willingness to pay. The effectiveness of various approaches to improving private insurance coverage of flood risk will also be discussed.

4.1 Investments in risk reduction

Investments in prevention to lower the probability of a flood event occurring or in mitigation to reduce the losses resulting from a flood event is a critical element in the financial management of flood risk. Such investments can also be particularly effective in the case of floods relative to other natural disaster risks (Botzen and van den Bergh, 2009) given the greater ability to protect communities and structures from water penetration through land-use planning, structural mitigation investments and household mitigation investments.

The types of prevention and mitigation investments can be grouped into three main categories: i) land-use planning and restrictions aimed at reducing the level of assets exposed to flood risk or reducing the impact of flooding through the use of natural mitigation measures (e.g. wetlands, mangroves); ii) community structural flood mitigation measures (e.g. flood defences, drainage systems) aimed at protecting particular areas against inundation; and iii) risk reduction at the level of individual properties (e.g. elevating a property). These types of investments are not mutually exclusive and should all be considered as part of a comprehensive approach to flood prevention and mitigation.

Analyses of the potential benefits of risk reduction in terms of reducing future losses have generally shown that risk reduction measures can create substantial benefits. The US Federal Emergency Management Agency has estimated, based on a review of 4 000 risk reduction programs, that the average cost-benefit ratio for investments in risk reduction is 1:4 (i.e. the benefits from risk reduction projects are 4 times the cost) (MMC, 2005). In the United Kingdom, the Environment Agency estimates that its capital investment in the flood and coastal erosion sector can achieve a whole life cost-benefit ratio of 1:9 or higher (Environment Agency, 2014).

Despite these potential benefits, there is some evidence of general under-investment in prevention and risk reduction. In the United Kingdom, an analysis by the Committee on Climate Change suggested that national government spending between 2011/12 and 2014/15 on flood and coastal erosion risk management was almost 20% below what the Environment Agency estimated as necessary to avoid increasing the number of households facing significant flood risk (Adaptation Sub-Committee Secretariat, 2014). However, this was recently addressed by a government commitment to increase investment at levels that are consistent with the Environment Agency's assessment of a long-term investment profile that maximises benefits in terms of reducing flood damage (Environment Agency, 2014b). A study by the International Federation of Red Cross and Red Crescent Societies estimated that USD 40 billion of investments in disaster

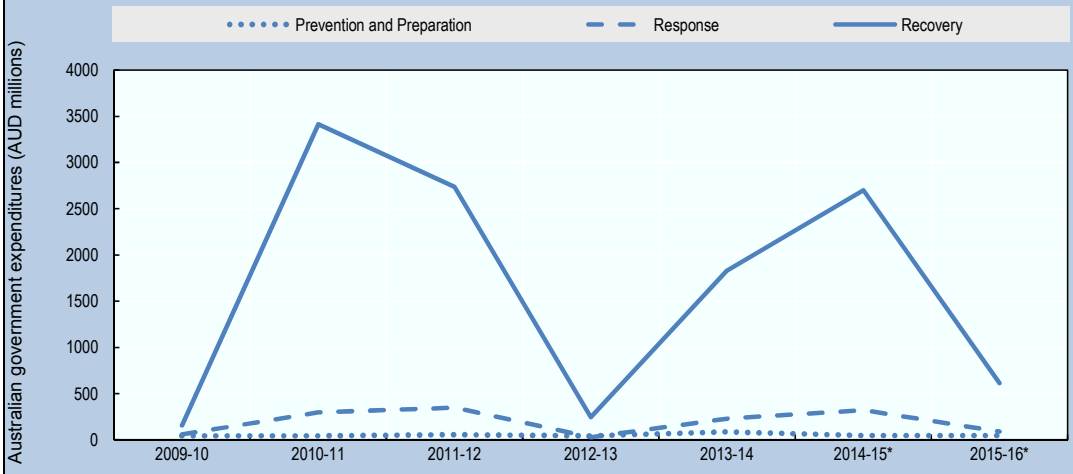
preparedness, prevention and risk reduction could have reduced global economic losses by USD 280 billion in the 1990s (IFRC, 2001).

Many countries allocate significantly more funds to disaster response than risk reduction. For example, the US federal government spent an average of over USD 3 billion on disaster response annually between 1985 and 2004 compared to USD 195 million on disaster prevention during the same period (Healy and Malhotra, 2009). In the past two decades, approximately 87% of the estimated USD 107 billion provided as development assistance for disaster risk management was devoted to post-disaster response and reconstruction, and only 13% was devoted to risk reduction and other *ex ante* risk management measures (Keating, A. et al., 2014). In its review of natural disaster funding arrangements in Australia, the Productivity Commission (2014) recommended a significant shift in funding towards prevention (and away from recovery) (see Box 4.1).

Box 4.1. **Australia Productivity Commission findings on prevention vs. recovery**

In Australia, within the federal system, constitutional responsibility for natural disaster planning, mitigation and recovery sits with state and territory governments. The Australian Government has a role in assisting with the burden of relief and recovery after major disasters and in collaborating with all levels of government to strengthen communities' resilience to natural disasters and minimise their impact. The Australian government provides financial assistance directly to state and territory governments for prevention and preparation, response and – in particular – recovery (see Figure 4.1).

Figure 4.1. **Estimated Australian Government natural disaster expenditure**



* Indicates estimates as the data was collected in mid-2014 and no adjustments since that time have been reflected in the data. Prevention and Preparation includes expenditures related to the National Emergency Management Projects, National Disaster Resilience Programme, National Bushfire Mitigation Programme, Betterment under the Natural Disaster Relief and Recovery Arrangements, National Flood Risk Information Project and Education training and research. Response includes expenditures related to the Crisis Coordination Centre, Counter-disaster operations of the Natural Disaster Relief and Recovery Arrangements, Defence Assistance to the Civil Community, National Aerial Firefighting Arrangements and Emergency Alert. Recovery includes expenditures related to the Natural Disaster Relief and Recovery Arrangements, Australian Government Disaster Recovery Payment, and Disaster Recovery Allowance

Source: Ward (2015).

Box 4.1 **Australia Productivity Commission findings on prevention vs. response** (cont.)

In 2014, the Australian Government asked the Productivity Commission to undertake a public inquiry into "the efficacy of current national natural disaster funding arrangements, taking into account the priority of effective natural disaster mitigation and the reduction in the impact of disasters on communities." The inquiry was specifically asked to examine "options to achieve an effective and sustainable balance of natural disaster recovery and mitigation to build the resilience of communities." Among the findings of the Productivity Commission (2014) is that post-disaster support to states and territories should be reduced while mitigation funding should be increased to AUD 200 million per year (which should be matched by the states and territories) – partly to ensure that states and territories are incentivised to invest in prevention. The Australian Government is consulting with states and territories on a modest and gradual approach to improving the balance between mitigation and recovery funding.

Source: Productivity Commission, 2014.

Land-use planning

Land-use planning can have a significant impact on flood risk by reducing the level of assets at risk of flooding (i.e. restricting development in flood zones) and therefore slowing the accumulation of assets exposed to flood risk. Inappropriate land-use development can have a significant impact on losses. For example, in Thailand, the construction of industrial parks on former swamps that had been subject to regular flooding was a major factor in what became the largest ever insured loss from inland flooding (World Bank, 2012). In the United States, high-risk (repetitive loss) properties accounted for 38% of all claims payments between 1978 and 2004 (US General Accounting Office, 2004).

However, land-use restrictions will only create benefits over time as the restrictions will only apply to new development, which accounts for a small share of the overall stock of structures in most countries. Efforts to prevent all new developments in floodplains may not be feasible particularly in high-growth countries and regions or in communities that lie completely within a flood hazard zone (Zurich Insurance Company, 2014). Only two countries (Estonia and Switzerland) indicated that changes in land-use have led to a significant reduction in flood risk while fourteen indicated that such changes had actually led to a substantial increase in flood risk – which suggests that few of the countries surveyed are achieving risk reduction through land-use planning restrictions. In Germany, for example, the increase in construction near rivers outpaces the rate of construction outside inundation zones, despite a 2004 law that forbids building and commercial usage of land prone to flooding (Schwarze and Wagner, 2007). In the United Kingdom, one-third of the projected three million properties to be built by 2020 are expected to be located on coastal and river floodplains (Risk Management Solutions and Lloyd's (2008)). In Italy, the effectiveness of strong legislative requirements for assessing flood hazard in new construction has been limited by gaps in compliance and a number of amnesties provided for properties that were constructed without regard to flood hazard levels (Swiss Re, 2015).

Relocation of communities in high-risk areas is one (very expensive and disruptive) means of addressing past weaknesses in land-use controls. Relocation has been implemented in a number of countries in a post-disaster context. For example, New York

State implemented a buyout program in high-risk areas affected by Hurricane Sandy that compensated participating homeowners the full pre-storm market value of their home (Kaplan, 2013). To mitigate against the possibility of community deterioration (as a result of some residents relocating while others stay), the program offered a 10% compensation premium for blocks of residents that participated in the program on a collective basis (Siders, 2013). Relocation programmes have also been implemented in Australia and New Zealand. The town of Grantham in Queensland, Australia was relocated to higher ground following deadly flash flooding in 2011 through a voluntary land swap program (Wilby and Keenan, 2012). In New Zealand (while not related to flood), homeowners in a high-risk "red zone" encompassing areas prone to earthquake damage (due to thin crust, liquefaction, lateral spread and/or cliff collapse) were offered buyouts at near market value. Over 95% of eligible property owners participated in the program leading to the purchase of 7 300 properties in the red zone (Mitchell, 2015). In Switzerland, an industrial zone in Preonzo was relocated to a safer area in 2013 and a number of residential properties in a community close to Lucerne were removed due an unbearable risk of potential rock fall. In both cases, the costs were partially (but not completely) absorbed by the public sector.

In many cases, relocation programmes suffer from low levels of participation. This could be the result of households' attachment to the community (e.g. friends, family, employment, sentimental attachment) or potentially related to some of the other factors that reduce the willingness of households to protect against disaster risks (underestimation of risk, expectation of government assistance). A survey by Bukvic, Smith and Zhang (2015) of flood-affected households on the determinants of relocation decisions found that an increase in insurance rates (along with the potential recurrence of flooding) would provide a major incentive to relocate which suggests that risk-based insurance premiums could play a role in encouraging land-use controls in flood-prone areas (as long as households are forced to/or choose to remain insured). Cash settlement of insurance claims (instead of insurer-organised reconstruction) may be one means of facilitating relocation by providing claimants with significant payouts that would provide the means to relocate (The Australian Government the Treasury, 2011).

Public support for the purchase of high-risk properties could remove an important barrier to relocation although the purchase of high-risk properties could create legal risks by providing an implicit acknowledgement of the government's responsibility for protecting citizens against flood risk (see Box 4.2).

In many countries, land-use policy is a matter for local jurisdictions which often face pressures to allow development of (generally desirable) land near water sources. Local governments also tend to benefit most from development (through the generation of local tax revenues) while the costs that developments in risky areas create when a flood occurs may be shared more broadly. The benefits of development can also be realised in the short-term while the costs of risky development may only be incurred in the distant future. A study of disaster mitigation plans in Florida and North Carolina, for example, found that federal policies and incentives (such as the Community Rating System – see Box 4.3) had little influence on the prevalence of land-use actions in local mitigation plans as local authorities demonstrated a preference for meeting federal requirements through less problematic risk reduction actions such as emergency response and public awareness (Lyles, Berke and Smith, 2014).

Box 4.2. **The role of liability in land-use planning**

Most governments would reject (and are careful to avoid any precedent for) a legal obligation to protect citizens against all disaster risks. For example, it would be reasonable to assume that the failure of an engineering structure, such as a dam, that results in flooding would create liability risks for the owner, operator and/or engineering contractor. A decision by a municipality to approve a development in a flood-prone area which is later flooded, on the other hand, would generally be considered as not subject to claims of liability directed towards the relevant decision-maker (Wilby and Keenan, 2012). However, in some countries, protection from liability for local planning decisions may not be assured. In Sweden, local councils have been found liable for flood damage in areas deemed unsuitable for development (Crichton, 2008). In the Netherlands, in the context of deliberations on the potential for a public-private partnership to provide natural disaster insurance, the Council of State (the supreme administrative court) advised against such a partnership as it could reduce the government's responsibility for the "habitability of land" (Jongjan and Barrieu, 2008), suggesting a potential obligation of the government that could have implications in terms of liability. The Productivity Commission (2014) review of natural disaster funding arrangements in Australia found some concerns among local governments about potential liability risk related to planning decisions and recommended that legislative protection should be provided to local governments for planning decisions taken "in good faith" (where such protections do not exist).

Source: Wilby and Keenan, 2012; Crichton, 2008; Jongjan and Barrieu, 2008; Productivity Commission, 2014.

In some countries, national governments can enact robust restrictions on land-use that must be applied by all local jurisdictions. For example, in Portugal, a national law forbids development in areas adjacent to rivers without pre-authorisation, even where the land is privately-owned. The size of the land subject to the restriction varies based on whether the river is affected by sea surge or tide or threatened by flooding (based on a 1-in-100 year return period) (OECD, 2014b). In Switzerland, a federal obligation for communities to undertake detailed hazard mapping has led to the incorporation of risk information into land-use planning in approximately two-thirds of Swiss communities (e.g. prohibitions on new building and reconstruction of destroyed buildings in high risk zones) (Federal Office of the Environment, 2015a).

National governments may also provide advice on and/or incentives for local land-use policies that reduce risk. In England, under the National Planning Policy Framework (Department for Communities and Local Government, 2012), the Environment Agency provides advice on flood risk to new developments and has been successful in influencing ultimate development decisions in some cases. In 2012/13, the Environment Agency's objections to local plans led to amendment in close to 99% of reported cases (DEFRA, 2013). National governments can also provide local governments with the necessary authorities for robust land-use planning. For example, in Denmark, national authorities passed legislation that specifically allows local governments to consider climate change and its risks in local planning decisions (OECD, 2013a).

Restrictions on access to insurance have been used in the United Kingdom as a means to influence local planning decisions where government reinsurance through Flood Re will not be available for developments constructed since 2009 (an approach established as part of the Statement of Principles agreement and to be maintained under Flood Re). This

means that should insurers offer coverage to home and business owners in those developments, they will not have access to Flood Re reinsurance (and therefore may be unwilling to offer insurance coverage at all), which should incentivise better land-use planning (the Association of British Insurers (2009) has also published guidance for developers on how to increase the likelihood of securing private flood insurance coverage for new developments). Similarly, in Russia, insurance is not available for unauthorised structures in floodplains. In the United States, a significant objective of the National Flood Insurance Program has been to encourage appropriate local land-use development. NFIP insurance is only available to households in communities that have agreed to implement FEMA standards related to floodplain development (see Box 4.3).

Box 4.3. **NFIP Community Rating System**

As a means of encouraging minimum standards of flood resilience in the United States, insurance coverage from the NFIP is only offered in communities (i.e. an administrative division with authority for enacting and enforcing development requirements) that agree to a set of flood management conditions, including building standards and floodplain management standards approved by FEMA, notably that structures be built above a base flood elevation level. These requirements have been estimated to have avoided USD 1.1 billion in flood losses per year and reduced the cost of flooding for an average residence in an SFHA from a 1-in-100 year event by over 65% (Sarmiento and Miller, 2006).

In addition, a Community Rating System (CRS) was established in 1990 as a voluntary program that communities may join. Communities that adopt recognised flood risk management practices (land-use planning and other risk reduction measures) above the minimum standards required for accessing NFIP insurance are awarded points. The points lead to a rating which in turn leads to a premium discount for households in that community (5% per rating level for those in an SFHA – up to 45%).

While only 5% of all communities have joined the program, those that have account for 68% of all policyholders (FEMA, 2015). Some communities have suggested that the burdens of entry into the program and of meeting the requirements for premium discounts have been a barrier to wider take-up, particularly among smaller communities with more limited risk management capacity (National Research Council, 2015). There is also some concern about the range of eligible measures, including both the ineligibility of some effective mitigation measures such as coastal sea walls and beach replenishment (Landry and Jahan-Parvar, 2011) as well as the eligibility of some measures (such as emergency response) which may be less effective in terms of reducing losses (Lyles, Berke and Smith, 2014). It has also been suggested that more points should be awarded for land-use planning given the relatively larger benefit of land-use restrictions in terms of reducing exposure (Lyles, Berke and Smith, 2014). However, an analysis of NFIP claims since 1998 found that households in communities with a high CRS rating (9 or above) submitted claims that were on average 13.5% lower than claims submitted by households in communities not participating in the program which suggests that the measures have been effective in reducing losses (Kousky and Michel-Kerjan, 2015).

Source: FEMA, 2015; National Research Council, 2015; Landry and Jahan-Parvar, 2011; Lyles, Berke and Smith, 2014; Kousky and Michel-Kerjan, 2015.

While restrictions on insurance in high-risk areas might enhance the effectiveness of land-use planning, the broad availability of affordable insurance coverage (or, alternatively, post-disaster government compensation) in communities facing significant flood risk could have the opposite effect by encouraging development in those areas and increasing the number of properties at risk.

Beyond establishing restrictions on development, land-use planning can also be used to increase the presence of natural flood protection mechanisms that can enhance water absorption and protect against storm surge. Natural flood defences, such as mangroves, wetlands, agricultural fields and green spaces, can provide significant benefits in terms of limiting the damage from coastal and inland flooding (OECD, 2016) and may be a more effective approach in areas that are already highly developed.

In the Netherlands, for example, the government initiated a "Room for the River Programme" that included the deepening of riverbeds and the establishment of 39 floodplains across major river systems (Orie and Stahel, 2013). The Netherlands has also established policies that encourage neighbourhoods to build floodable parks (Orie and Stahel, 2013). In Copenhagen, a "Cloudburst Management Plan", developed in response to extreme flash flooding in 2011, takes a comprehensive approach to leading rain waters to green and blue spaces that can absorb the water, including by designing streets to acts as urban waterways for the drainage of rain waters. Wetland and floodplain restoration is also being used to manage flood risk in other European river systems, such as the Danube (Ebert, Hulea and Strobel, 2009), and in Switzerland where many communities have widened riverbeds and predefined areas to be used as floodplains. In Australia, the Victorian State Government is buying land in order to restore it to natural floodplain functions.

The conservation and restoration of mangroves and coastal wetlands has also proven effective in providing protection against coastal floods and storm surges. Mangroves can reduce wave height by as much as 66% over 100 meters of forest (McIvor et al., 2012). For example, the "value" of coastal wetlands in the United States in terms of providing protection against hurricanes has been estimated at USD 23 billion per year (i.e. the estimated value of losses avoided as a result of the protection provided by wetlands) (Costanza et al., 2008). In Viet Nam, the protection of 12 000 hectares of mangroves (at a cost of USD 1.1 million) saved an estimated USD 7.3 million in annual dyke maintenance costs (Kay and Wilderspin, 2002).

Structural flood mitigation

Structural flood mitigation measures, such as dams, levees and reservoirs as well as natural mitigation approaches such as the re-forestation of drainage basins, may be used to reduce flood risk by protecting areas from a given level of inundation and therefore reducing the frequency of flooding. Such measures may be the only cost effective approach to reducing flood risk in built-up areas located in floodplains (Productivity Commission, 2014). Improvements to urban drainage systems as well as the installation of permeable pavement (which is mandatory in the United Kingdom) can also be effective in improving water absorption capacity in urban areas. For example, improvements to the urban drainage systems in Mumbai could potentially reduce direct and indirect losses from a 100-year flood by 70% (Ranger et al., 2011). Due to the size of the investment needed, large structural mitigation investments tend to be most cost-effective where the value of assets protected is also very high (such as urban areas) (i.e. the benefits in terms of avoided losses justify the large cost of investment). In many major cities, including London, Tokyo and Bratislava, flood protection levels of 200-years or more have been established or are under development (OECD, 2014).

Box 4.4. **The impact of structural flood mitigation investments: Some examples**

While individual flood events will usually differ from previous events, similar flood events affecting the same areas before and after an investment in flood mitigation as well as modelling techniques can be used to provide some insight into the benefit of structural mitigation in terms of reduced losses.

Similar flooding events affected parts of Germany, Austria, the Czech Republic and Switzerland in 2002 and 2013. Both events were caused by unusually high levels of spring precipitation followed by periods of intense rainfall that led to flooding as water could not be absorbed by saturated ground. The 2013 event involved higher reported water levels across most river gauges along the Danube and Elbe rivers and their major tributaries. However, the level of economic losses from the 2013 floods was relatively similar to the 2002 floods (EUR 12 to 16 billion relative to EUR 15 billion in 2002) despite the continued accumulation of assets and higher water levels. Cities such as Prague and Dresden managed to avoid major losses altogether in 2013 (relative to significant losses in 2002) through the installation of new structural mitigation measures. The number of levee failures declined to 5 major failures in 2013 relative to 13 in 2002. Similarly, an increase in the height of a dam in Munich by three meters likely saved the city from significant flooding in 2013 (Zurich Insurance Company, 2014).

The USD 125 billion in losses generated by Hurricane Katrina in the United States in 2005 remains the largest ever loss event globally from a tropical cyclone. Since that time, significant investments have been made in improving the structural protection around the city of New Orleans, which accounted for the largest share of damage from the hurricane, as a failure of the previous protection system was a significant driver of the level of damage. This has included the construction of a USD 14.5 billion storm surge defence system involving levees and floodwalls, pumping stations, canal closures and gated outlets as well as the adoption and enforcement of stricter building codes across the state of Louisiana. A simulation of the potential impact of a similar storm today, undertaken by a catastrophe modelling firm, estimated that losses across the 6 affected states (Alabama, Florida, Georgia, Louisiana, Mississippi, and Tennessee), assuming the storm surge defence system is able to protect the city of New Orleans, would decline substantially to approximately USD 71 billion, despite a 40% increase in the insured value of coastal property in Louisiana and a 36% increase in Mississippi (the two most affected states) (AIR Worldwide, 2015).

Modelling techniques have also been used to estimate the benefits of investments in coastal defences in the city of Hamburg since a storm surge in February 1962 reached 5.7 meters above sea level, killed 318 people and caused losses equivalent to EUR 1.6 billion (in current values). Flood protection infrastructure was reinforced and raised to protect against a storm surge of 8.0 meters above sea level at a cost of approximately EUR 2.2 billion. According to calculations by a reinsurance company, these investments have protected the city from coastal flooding (at levels above the level reached in 1962) four times since then resulting in savings of EUR 17.5 billion in losses not incurred (taking into account inflation and increasing asset values) (Munich Re, 2012).

Source: Zurich Insurance Company, 2014; AIR Worldwide, 2015; Munich Re, 2012.

Structural flood mitigation investments are a common measure for addressing flood risk in most countries and are generally considered effective (see Box 4.4). Almost all surveyed countries (seventeen of twenty) indicated that structural mitigation investments have led to a reduction in flood risk with some respondents suggesting that it is likely the

largest contributor to reducing flood risk in their country. In Ireland, for example, an estimated 6 000 properties have been protected since 1995 with structural mitigation investment expected to lead to a reduction of EUR 1 billion in exposure over the life of the investments. In Switzerland, EUR 25 million in investments in structural measures to protect the commune of Buochs on Lake Lucerne against flooding from the Engelberger Aa river prevented an estimated EUR 150 million in damages from flooding in 2005 (Federal Office of the Environment, 2015b). In Portugal, new drainage infrastructure in Lisbon is being assessed as a possible solution to high-levels of flood risk. In Australia, mitigation investments are seen as a possible means of balancing the demand for development in highly-desirable waterfront locations and in the outskirts of urban areas with the need to manage flood exposures.

However, many countries noted significant barriers to implementing structural mitigation investments as a strategy for the financial management of flood risk. Large structural investments are costly and a number of countries noted significant challenges in terms of accessing the needed public funding (both for initial construction and ongoing maintenance). The time horizon of political cycles makes the avoidance of potential losses at some future time a less attractive rationale for the use of scarce public investment resources. In the case of the Czech Republic, securing resources for mitigation investments outside of large urban areas was identified as particularly challenging. In built-up areas, there are additional challenges related to securing community support for investments that – while providing enhanced protection against floods – limit direct access to shorelines or create blots on the landscape. The long-term effectiveness of structural mitigation was also identified as a potential challenge in light of the uncertain impacts of a changing climate on flood risk (see Box 4.5).

Box 4.5. **The design of structural mitigation investments in a changing climate**

In many cases, the life of large mitigation investments will span well beyond the 21st century and therefore such structures are almost certain to be tested against the impacts of climate change. Extreme but plausible scenarios, such as a global average temperature increase of 6°C (the approximate average projected temperature increase for the year 2100 in a scenario of increasing carbon dioxide emissions), could have significant implications on planning assumptions over long time horizons. For example, in the Netherlands, a 6°C scenario could lead to mean rise of (non-storm surge) sea levels of 4 meters along the coast in 2200 (Vellinga et al., 2009). Given the significant costs that usually come with attempts to increase the protection level of existing mitigation infrastructure – and the significant costs that could be incurred as a result of a breach of that infrastructure – such extreme scenarios may need to be considered in the design of current investments.

A number of countries are implementing such an approach. For example, the Netherlands Delta Committee, tasked with providing advice on long-term flood protection in the context of climate change, considered high-end climate scenarios out to 2200 in its assessment. The Thames Estuary 2100 study also used a “high-plus-plus” climate scenario in its assessment of options for providing flood protection for London out to 2100 (Wilby and Keenan, 2012). In Germany, the *landers* of Bavaria and Baden-Württemberg have introduced a "climate surcharge" into the design of all flood-related structures (i.e. the (calculated) design flood discharge value (projected flood) is augmented by 15 % to account for climate change).

Source: Vellinga et al., 2009; Wilby and Keenan, 2012.

Governance was also identified as a challenge to effective structural mitigation of flood risk, including the difficulty in coordinating across the various agencies involved. The difficulties in ensuring coordination among agencies are exacerbated where river basins and/or exposed communities cross administrative lines. An assessment by the OECD (2014a) of resilience to floods in the Seine basin in Île de France found that institutional fragmentation between administrative levels has been an impediment to building resilience against flood risk.

In a few countries, the availability and affordability of insurance has been a consideration in decisions on investments in structural mitigation measures (although only 30% of respondents to the survey identified any significant relationship between the two issues). For example, in Australia, a range of specific mitigation investments have been made by the government to reduce the potential for loss and support effective private insurance coverage in areas severely affected by the 2010-11 Queensland floods. The relationship between insurance availability and mitigation was also at the core of an agreement between the UK government and insurance sector that preceded the establishment of Flood Re (see Box 4.6).

Box 4.6. **Investments in mitigation and insurance availability in the United Kingdom**

Prior to the establishment of Flood Re in the United Kingdom, the insurance industry and the UK government had a long-standing arrangement for the provision of flood insurance coverage by the private insurance industry (known initially as the "Gentleman's Agreement", later replaced by the "Statement of Principles"). Initially, the arrangement guaranteed the availability of flood insurance as part of bundled household insurance coverage for all residential properties. In 2002, however, the arrangement was limited to providing a guarantee of the availability of coverage for all residential properties facing a level of flood risk below 1-in-75 years. In 2005, the Statement of Principles extended insurers' commitment to provide coverage for residential properties (and small business) where the flood risk level was expected to improve to below 1-in-75 years within five years as a result of investments in flood protection. In areas with higher levels of flood risk, the availability of insurance coverage was not guaranteed and would be considered on a case-by-case basis. The Statement of Principles was extended in 2008 for a last 5-year period and was amended to exclude any property built after 1 January 2009, on the basis that no further development should occur in areas with flood risk levels above a 1-in-75 year return period (DEFRA, 2013).

These agreements aimed to ensure broad availability of flood coverage from the private insurance industry, supported by a commitment from the government to implement structural and non-structural measures (flood maps, flood defences and land-use planning) to manage the level of flood exposure – and have often been identified as a best-practice in terms of public-private collaboration on the financial management of flood risk (e.g., Thistlethwaite and Feltmate, 2013; Swiss Re, 2012). They provided the government with a means for ensuring broad insurance coverage of private flood losses and the insurance sector with a means to compel government into making sufficient investments in flood mitigation. However, over time, dissatisfaction with the level of government investment (along with concerns about ensuring a level-playing field relative to new insurance market entrants not subject to the agreements) played a role in the replacement of the agreement through the establishment of Flood Re. Flood Re will operate with a continued government commitment to investments in flood defences and appropriate land-use controls (through a letter of comfort that will be provided by government) (Surminski and Eldridge, 2014).

Source: DEFRA, 2013; Thistlethwaite and Feltmate, 2013; Swiss Re, 2012; Surminski and Eldridge, 2014.

Investments in structural flood mitigation should lead to reductions in insurance premiums for private property within communities benefitting from enhanced levels of protection. For example, in Australia, one insurance company announced that premium reductions of 30 - 80% could be expected once the construction of a new levee was completed (Suncorp Insurance, 2013). These premium reductions (even expected future reductions) could be considered a potential source of funding for mitigation. Local governments investing in mitigation could consider recouping some of the expected savings that will benefit their residents through specific charges/taxes. For example, a community that invests in mitigation measures that lead to a NFIP premium discount for policyholders within the community under the Community Rating System could conceivably impose a tax for some or all of the amount of the expected premium discount in order to finance those investments.

Insurance companies themselves might also be a potential source of financing for structural mitigation. Insurance companies manage more than USD 28 billion in assets on behalf of policyholders and third parties (OECD, 2015b) and have a self-interest in supporting investments in resilience as a means of reducing losses over time. Governments could capitalise on this potential demand from insurance companies for supporting investments in resilience by issuing bonds for the express purpose of financing such investments. This emerging bond type, known as "resilience bonds" or "municipal adaptation bonds", is similar to the concept of "green bonds" whereby the issuer commits to use the funds for specific "green" purposes. In fact, such investments are usually considered to be an eligible use of proceeds from green bonds. Investment in climate change adaptation is included as an eligible use of funds under the Green Bond Principles. The Climate Bonds Standard and Certification Scheme, which aims to establish standards for "green" municipal bonds, includes investments in flood mitigation as an eligible investment that can be financed with the proceeds of a green municipal bond (US Green City Bonds Coalition, 2015). The City of New York announced in 2014 that it intended to issue ("green") bonds for the specific purpose of financing projects that would boost resilience to climate change (Owens, 2014). Green bonds have also been issued by Nederlandse Waterschapsbank (NWB Bank) to finance loans to Dutch water authorities for water management measures, including flood protection measures (Kidney, 2016).

Insurance companies are also significant investors in infrastructure. However, the potential for private investment in resiliency projects is limited by the challenge in structuring an approach that provides the investor with returns over time. Unlike toll roads or airports, structural mitigation projects such as flood barriers do not generate future revenue with which to repay investors and are therefore usually financed by public funding. One approach put forward to address this barrier is to link investments in resilience to pre-defined rebates on catastrophe bonds that could be used to fund the project costs (Vajjhala and Rhodes, 2015) - although a significant increase in interest in catastrophe bond issuance by public agencies would be a prerequisite. Regulators may want to consider whether the capital or liquidity treatment of investments in resilience bonds or resiliency projects is appropriate given the potential benefits of investments in structural mitigation for reducing exposure to flood losses.

Careful consideration also needs to be given to some of the potential negative impacts of flood protection infrastructure. Structural defences can (and do) fail with significant consequences. While the number of levee failures during the 2013 Central Europe floods were lower than in 2002, 19 levees still failed in Saxony alone, including 5 major breaches (Zurich Insurance Company, 2014). Losses would reach an estimated

USD 105 billion in the case that the New Orleans' storm surge system failed under the hypothetical Hurricane Katrina-like scenario described in Box 4.4 (AIR Worldwide, 2015). The flood mitigation infrastructure itself can also increase losses from flooding if it is damaged in the event and/or it slows the dispersion of floodwaters after the event (Crichton, 2008).

Household risk reduction

In addition to investments in risk reduction to protect flood-prone areas, there are a number of measures that can be taken at the level of individual households to either limit the damage when flooding occurs or prevent inundation altogether. These include elevation of structures above flood water levels, elevated curb stones to prevent water entry from smaller events, reinforcement of foundations and cladding to avoid structural damage from fast-moving waters and/or debris, moving building contents (and particularly electrical installations) above flood water levels (either temporarily in the event of a flood or permanently), dry flood proofing to make areas below flood water levels water tight and temporary or permanent flood walls (ranging from sand bags to free-standing concrete barriers). Some of these measures are extremely costly for existing structures. For example, raising the ground floor of an existing building above floodwater levels could cost GBP 30 000 (or 35-50% of a typical home value in the United Kingdom) (Risk Management Solutions and Lloyd's, 2008) and may not be possible if the existing ceiling is too low. Temporary measures, such as the placement of temporary flood barriers may be more cost-effective than some of these permanent measures (depending on the frequency of flooding) (Wilby and Keenan, 2012).

A number of empirical assessments of the effectiveness of household risk reduction investments have found significant benefits in terms of reducing losses from floods. A study on the impacts of the Elbe River floods in Germany in 2002 found that flood adapted buildings faced 46% less damage to structures and 48% less damage to contents; flood-adapted interior fittings reduced damage to buildings and contents by 53%; and placing utility and electricity installations on higher floors reduced flood damage by 36% (Kreibich et al., 2005). In the United States, elevating a structure has been found to reduce claims as a share of building costs by 16% to 18% (at a cost of approximately USD 50 000 to USD 70 000 to elevate an existing home) (Kousky and Michel-Kerjan, 2015). Buildings constructed to meet stricter NFIP requirements after 1975 have been found to face six times less damage than those built pre-1975 (Pasterick, 1998).

Damage prevention efforts by residents in Cologne (Germany) were found to have been the primary factor in reducing damage from two floods with similar floodwater levels in 1993 and 1995 from EUR 65 million to EUR 30 million (Fink, Ulbrich and Engel, 1996). The International Commission for the Protection of the Rhine (2002) estimated that investments in long-term mitigation (e.g. protective water barriers and, particularly, the replacement of oil heating installations located in basements with gas heating installations located under ceilings) by households and firms could reduce monetary damages by 80%. Modelling of hurricane damage in the United States, comparing current building standards relative to legacy standards, found that losses could be reduced by 34% to 61% (depending on the state) if all structures were brought to current building standards (Kunreuther et al, 2008). High-resolution flood models have found significant changes in the level of damage to a given structure (10x or more) based on small variations in a building elevation or level of protection (R. Muir-Wood, 2014, personal communication, 21 August). A broad assessment of the cost-benefit ratios for household flood mitigation measures in 34 flood-prone developing countries found an

average of 1:60 for constructing a one-meter wall around houses and 1:14.5 for elevating houses in flood-prone regions (Kunreuther and Michel-Kerjan, 2013b).

Despite these benefits, most studies that have examined the willingness of households to invest in flood mitigation have found little interest in such investments. A survey of US residents along the Atlantic and Gulf coasts in 2006 (after the record 2005 hurricane year) found that 83% of respondents had not taken any steps to fortify their homes (Goodnough, 2006). Surveys of earthquake-prone homeowners in California in 1989 found similar levels of inaction (only 5-9% of respondents had adopted any loss reduction measures) and little change over 15 years of attempts to increase public awareness of earthquake risks (Palm et al., 1990). Even where households have made an initial investment in purchasing protective materials, they may not take the additional step of installing those materials. For example, a survey of residents in coastal New York counties during Hurricane Sandy found that less than half of those that had purchased storm shutters had actually installed them before the hurricane (Meyer et al., 2013).

The reasons behind households' reluctance to invest in risk reduction are likely similar to the reasons behind households' limited willingness-to-pay for insurance coverage outlined in Chapter 3 (low risk awareness, expectation of government assistance, etc.). However, households' reluctance to invest in protecting themselves is likely to be exacerbated in the context of risk reduction investments that are generally more costly than an annual insurance premium – particularly in countries with high-levels of mobility where homeowners sell their homes more frequently. Household decision-makers may also exhibit myopic behaviour where they focus solely on the potential benefits of an investment over a short period of time, such as 2-3 years, and therefore underweight the benefits of mitigation investments over the longer-term (Kunreuther and Weber, 2014).

A number of countries have implemented funding programmes (either temporary or permanent) to support flood protection at the household level. National and local authorities in England provide funding for property-level mitigation measures (up to GBP 4 750 is available per household from the national government) (DEFRA, 2013). The government of Alberta (Canada) established a program to provide funding support to residents to invest in self-protection after the 2013 floods in Calgary (Stelmakowich, 2013). In the United States, federal public funding is available for property-level risk reduction both pre- and post-disaster. The pre-disaster programmes support building elevation, relocation, demolition and rebuilding for all types of properties and flood-proofing for commercial structures. A portion of the pre-disaster programme funding comes from the National Flood Insurance Fund and therefore from insurance premiums. Funding has varied significantly from year-to-year and demand for the programs has been well-above capacity (National Research Council, 2015). The federal post-disaster programmes are triggered by a presidential disaster declaration and respond to applications from states who disburse the funds to local governments for use at individual properties. Homeowners with a NFIP policy can also access up to USD 30 000 in "Increased Cost of Compliance" payments as part of a post-flood claim to bring a structure into compliance with current building standards, including base flood elevations (where applicable) (Kousky and Kunreuther, 2014). As in the case of structural mitigation investments for communities, there may be a case for targeting funding programs towards areas where there are difficulties in terms of insurance availability or affordability (National Research Council, 2015).

There may also be opportunities to use post-disaster funding for mitigation to leverage funding from insurance companies for risk reduction. Insurance companies will rarely pay for risk reduction improvements (or "betterment") of flood damaged properties covered by insurance (Wilby and Keenan, 2012) as resilient reinstatement of a damaged property can cost 40% or more than standard reinstatement (Wassell et al., 2009). Public funds, that might normally be available for post-disaster mitigation investments, could potentially share the costs of betterment in situations where insurance companies would not normally assume such costs. It has been suggested that post-disaster grants to households for resilience measures after floods in 2013-14 in the United Kingdom could have been made more effective in terms of reducing risks if the use of the grants was coordinated with insurance companies involved in rebuilding insured properties (which might also facilitate future premium reductions) (CII New Generation Programme Claims Group, 2015).

The attractiveness to households of risk reduction investments would become more obvious if such investments lead to (future) discounts in the premium paid for flood insurance. For example, a survey of homeowners in the Netherlands found that two-thirds of respondents would be willing to invest in water barriers, about a fifth would be willing to install water-resistant floor types and a quarter would be willing to move central heating installations to upper floors if such investments would lead to a reduction in their insurance premium (Botzen et al., 2009). In order to provide such discounts, insurance companies would need to be sure that the risk reduction investments would be effective in reducing future losses, which would require some assurance that the measure will be properly implemented and maintained. It may also be much more difficult for an insurance company to quantify the reduction in exposure expected from non-engineered small-scale measures (Ball, Werritty and Geddes, 2013). These types of concerns may be a factor in the relatively low number of countries where premium discounts are commonly available for risk reduction measures. Only eight of the twenty-seven surveyed countries indicated that premium discounts related to mitigation investments were possible and generally only in some cases or for some lines of business (such as commercial). A survey of German insurance companies found that only 14% rewarded voluntary private risk reduction measures (Thieken et al., 2006).

Some countries have implemented initiatives to help translate mitigation investments into meaningful assessments of reductions in losses. In Germany, a programme has been established to allow households in flood exposed areas to obtain a flood resilience certificate that is based on an extensive risk assessment by authorised experts (OECD, 2015a). Property owners can seek a flood pass ("Hochwasser Pass") that provides an assessment of the individual flood risk for a given structure and particular mitigation measures that could be implemented to reduce that risk. The flood pass can also be used to support access to insurance for properties that can demonstrate acceptable levels of flood risk. A similar approach, based on the Energy Performance Certificate required to attest to a structure's energy use and cost in the event of sale or lease of a property, has been proposed in the United Kingdom (CII New Generation Programme Claims Group, 2015). In the United States, specific guidance on mitigation has been developed by FEMA and some measures (including elevation, wet-proofing and permanently moving contents to a higher level) can lead to lower NFIP premiums (National Research Council, 2015). Under the *Biggert-Waters Flood Insurance Reform Act of 2012*, FEMA is required to examine the potential for other measures to lead to premium discounts. In the United Kingdom, a standardised "flood risk report" is made available by the government for use by surveyors in reporting on flood resistance and

resilience measures implemented for a given property (DEFRA, 2013). In Florida, legislation has been introduced requiring insurance companies to provide discounts, rate differentials or reduced deductibles for properties where mitigation investments demonstrated to reduce wind losses have been implemented (Warner et al., 2009). In Australia, the government has provided funding for an inspection scheme to undertake building assessments on multi-residence structures in North Queensland where insurance affordability has been a challenge (The Australian Government the Treasury, 2015a).

Premium discounts are also important for reducing the moral hazard that insurance coverage might otherwise create. While households will always have an interest in protecting their belongings from flood damage, the financial incentive for risk reduction measures will not be as strong if the implementation of such measures has no impact on the cost of insurance. That said, there is some evidence from Germany and the United States that insured households have a higher tendency to implement self-protection measures than uninsured households when faced with potential flooding, despite the lower losses insured households would be expected to bear (Thieken et al., 2006 and Hudson et al., 2014).

Another potential approach to improving the incentives for household-level mitigation would be to provide financing for the costs of mitigation based on the expected future reductions in premium levels. For example, a homeowner with limited current financial capacity to fund mitigation investments should be able to seek a loan for those investments as long as the investments will lead to future premium discounts that could finance the repayment of the loan. As an example, one study estimated that a loan of USD 25 000 to elevate a home (with a term of 20 years and an interest rate of 3%) would cost USD 1 680 per year to service but lead to a reduction in premiums of close to USD 3 500, creating net savings of USD 1 800 per year (Kunreuther and Michel-Kerjan, 2013a). Such loans could be extended by the private or public sector, could be included as a package with flood insurance, and/or could be multi-year and transferable to purchasers of a given home (in order to provide an easier repayment schedule for large investments) (Michel-Kerjan, 2010; Kunreuther and Michel-Kerjan, 2013a; National Research Council, 2015). It could also be part of a premium subsidy provided to homeowners in high-risk areas to support the affordability of flood insurance (see section below).

Tax incentives could be another means of encouraging investments in mitigation although such approaches tend to disproportionately benefit those in higher income tax brackets. In the United States, a legislative proposal has been introduced that would provide a tax credit of up to USD 7 500 for qualifying mitigation expenses by individuals and SMEs that hold an NFIP policy and benefit from subsidised premiums (National Research Council, 2015). Another proposal being considered in the United States is to create a Disaster Savings Account that would allow homeowners to contribute up to USD 5 000 annually (pre-tax) to save for uninsured damages and/or investments in a list of qualifying risk reduction measures. Amounts withdrawn for qualifying expenses would not be taxed (National Research Council, 2015).

The benefits of a comprehensive approach to risk reduction

The use of land-use planning, large-scale structural mitigation and household risk reduction measures to address flood risk need be considered in a holistic way to be effective. For example, structural investments risk being ineffective if not supported by appropriate land-use controls. Without appropriate land-use controls, investments in flood defences could encourage development of newly-protected areas which could increase

losses were the defences to be breached. One of the respondents to the survey (Turkey) noted that efforts to reduce flood risk through significant investments in structural flood mitigation were being undermined by land-use changes that continually expanded the land area at risk through new developments (and also increased the demand for further structural protection).

A combination of measures can have a significant impact on future exposures, even taking into account the increasing hazard levels expected to accompany climate change. For example, a case study for the North European coast estimated that a combination of sea flood defences and individual property measures could reduce the 75% increase in losses expected with a 30 cm rise in sea-levels by 95% (Risk Management Solutions and Lloyd's, 2008). In Florida, an estimated 40% of expected losses accompanying a high climate change scenario could be avoided through the construction of levees, better management of vegetation and changes to building standards for houses and apartments (Swiss Re, 2010).

The objective for flood risk management planning should be to find an optimal portfolio of the flood risk management tools available, weighing the costs and benefits of the different investments and taking into account the cumulative benefits from different types of tools when combined. One approach might be to consider different possible flood risk reduction investments as a portfolio of investments and aim to optimise the return (and minimise risk) across a set of possible flood risk reduction investments (Aerts et al., 2008).

To support an integrated approach to flood protection, post-disaster assistance for "betterment" might benefit from allowing flexibility in the use of funds. In the United Kingdom, some local councils allowed households to pool funds received through Repair and Renew Grants provided after 2013-14 flooding to finance larger flood defence measures seen as more effective in providing protection at the community-level (CII New Generation Programme Claims Group, 2015).

4.2 Mapping and modelling of flood risk

As noted in Chapter 3, a key challenge to the insurability of flood risk is impediments to the accurate assessment of flood exposures, including the complexity of modelling flood risk as well as the uncertain impacts of climate change on precipitation and storm patterns going forward. Accurate risk maps that provide estimates of frequency and assessments of impacts on structures for all types of floods are critical for land-use planning and risk reduction investments, and underpin the pricing of insurance premiums. In a number of countries, a lack of high-quality maps that provide an up-to-date assessment of the level of flood risk by geographical area has been a significant impediment to effective financial management of flood risk as well as private insurance coverage of flood risk (see Box 4.7).

Flood hazard maps are usually prepared by public authorities and/or commercial vendors and provide information on flood probability based on the extent of potential flooding, water levels and/or flow velocity under different flood scenarios. These types of maps are tailored to the needs of public land use planning, where one application may be the establishment of restrictions on new development in high hazard areas. However, these types of maps are insufficient for the purpose of insurance coverage, where information on potential consequences of flooding is also necessary. Flood risk maps that provide information on the potential consequences of flood hazards based on information

on structures located in inundation zones are more useful but less commonly available. At the time of writing, scenario-based catastrophe models have been developed by the (re)insurance sector and are also available from vendors for a few Latin American and Asian countries (Argentina, Mexico, Ecuador, Paraguay, Papua New Guinea, South Korea, Viet Nam and New Zealand). Fully probabilistic flood catastrophe models, which provide information on potential damages (including insured damages) at different levels of probability, are only available from vendors for a few countries, such as the United States (including storm surge for the Gulf and East coasts), Canada, Austria, France, Poland, Switzerland, Belgium, Netherlands, Hungary, Czech Republic, Slovakia, Germany, the United Kingdom, Mexico, Brazil, Indonesia, and Australia.

Box 4.7. **Mapping challenges: Canada, Australia and the United States**

A common challenge in countries facing diverse levels of flood risk across their territories is the maintenance of consistent, high-quality and updated flood risk maps:

- In Canada, the quality of maps developed by conservation authorities and municipal, provincial and federal governments has been a significant impediment to private insurance coverage. The flood maps: i) do not provide sufficient information on the location and cost of potential damage or the frequency of flooding; ii) use different flood return periods for different regions within Canada (e.g. 1-in-100 in Alberta, 1-in-250 in British Columbia and various return periods in Ontario); iii) are outdated and therefore do not capture changes in urbanisation or climate change impacts; and iv) do not generally include flash flooding (Thistlethwaite and Feltmate, 2013 and Insurance Bureau of Canada, 2015).
- In Australia, a submission from Allianz Australia Insurance Ltd. (2011) to the Natural Disaster Insurance Review indicated that, with the exception of New South Wales, flood maps made available by local councils were not of sufficient quality to allow them to offer insurance coverage.
- In the United States, consultations with risk modelers found limited confidence in the reliability of flood maps prepared by FEMA. Among the findings from these consultations were that the maps: i) are based on less-sophisticated methodologies than are currently available; ii) underestimate base flood elevations (and therefore flood risk to structures); and iii) are unable to account for important factors such as changing climate patterns, building stock growth and the interaction between different bodies of water (GAO, 2014). A US GAO (2008) report suggested that 50% of FEMA flood maps were more than 15 years old and 8% were 10-15 years old in 2008. More recent statements by FEMA suggest progress, although 40% of maps are still considered in need of review and 10% are considered out-of-date (Simpson, 2014).

Source: Thistlethwaite and Feltmate, 2013; Insurance Bureau of Canada, 2015; Allianz Australia Insurance Ltd., 2011; GAO, 2014; GAO, 2008; Simpson, 2014.

A number of countries are making significant investments to improve the quality of mapping. For example in Australia, a National Work Program for Flood Mapping aimed at improving the quality and consistency of flood mapping has been established. Under the programme, an analysis of gaps in coverage of existing maps is being undertaken in order to support the prioritisation of future investments in flood mapping. To ensure national consistency, principles and technical standards for flood risk mapping are also being developed and its outputs will apply across all jurisdictions within Australia (and

therefore, will aim to avoid differences in methodologies that might undermine the usefulness of flood maps for end-users, including the insurance industry). In the United States, FEMA requested USD 400 million annually over fiscal years 2013-2017 to develop more accurate flood maps and address some of the shortcoming identified in Box 4.7 (although FEMA has indicated that it will take several years to bring all the maps up-to-date (Simpson, 2014)). Turkey is also investing in flood mapping with the aim of completing risk maps by 2017.

In the European Union, the implementation of the Flood Directive (Directive 2007/60/EC) has been an important driver of improvements to mapping in many countries (Surminski et al., 2014). The Directive requires member countries to undertake detailed flood risk mapping for areas identified as high-risk (based on a preliminary flood risk assessment) and to update those maps every six years. For example, in Austria, the implementation of the Directive has required the completion of flood risk maps for 391 areas facing potentially significant flood risk. Ireland has completed a preliminary flood risk assessment and is nearing completion of detailed risk mapping for 300 communities facing potentially significant risk. Portugal has completed a flood risk and vulnerability mapping exercise that considers the potential impact of various climate change scenarios. The United Kingdom has completed national and locally-detailed surface water flooding maps in response to the Directive and recommendations from the Pitt Review (2008) on lessons from the severe 2007 flooding in England (Surminski et al., 2014). In Switzerland, cantons and communities are obliged by federal law to establish hazard maps for a series of natural perils, including floods, with a resolution down to the individual lot or parcel.

The availability of risk maps suitable for underwriting flood insurance coverage is often driven by demand from a private insurance sector in need of modelling and mapping in order to assess flood risk. In a US GAO study (2014) on means to enhance private sector involvement in providing flood insurance, those consulted anticipated private insurance company interest in underwriting flood risk would drive demand for modelling and attract risk modelling firms to invest in building accurate risk maps for US flooding. As the environment for private sector coverage of flood risk improves in the United States, new probabilistic inland flood models are already being released (Miranda, 2014). Similarly, in Canada, the announcement of the government's intention to "explore options for a national approach to residential flood insurance" (Department of Finance Canada, 2014) has coincided with the development of flood risk models for Canada by several major reinsurance brokers and catastrophe modelling firms.

Even where private sector modelling and mapping of flood risk is well-established, governments have a role to play in ensuring the availability of the data necessary for developing and maintaining flood risk models. Governments are a significant provider of satellite imagery and are also the major source of most meteorological and hydrological data for their territories. Investments in building the capacity of meteorological and hydrological services generally provide broad benefits (not just in terms of better data for modelling flood hazards). According to the World Meteorological Organisation, estimates of cost-benefit ratios for investments in meteorological and hydrological infrastructure are generally around 1:10 (Jarraud, 2007). The potential benefits of upgrading all developing country hydrometeorological information production and early warning capacities to developed country standards have been estimated to be between USD 4 billion and USD 36 billion on an annual basis (Hallegatte, 2012).

Technological advancements are making an important contribution to the quality of flood risk maps. The availability of higher-resolution digital terrain models have allowed for more granular flood risk modelling that is able to provide greater differentiation in risk levels based on more accurate assessment of the probability of inundation. Satellite imagery has provided modellers with an accurate picture of the footprint of past floods that can improve the calibration of existing models. The increasing availability of satellite data has also allowed greater geographical coverage of flood maps, including into areas where no other mapping or modelling capacity is available. Google Earth™ and other publicly-available satellite data allow underwriters to estimate critical variables such as the distance of a structure from water and the elevation of the structure relative to that body of water. These advancements could contribute to increased insurance availability for flood risk in countries where risk mapping (and even hazard mapping) is not available as insurers do underwrite commercial risks in many countries where risk maps are not available (Thistlethwaite and Feltmate, 2013).

While experience from past events should not alone drive the identification of areas at risk of flooding, data on past losses is critical for calibrating (and re-calibrating) flood models. Real-world experience provides modellers with information on key inputs such as levels of water absorption for a given precipitation event, levels of flood damage for a given floodwater level (and the accuracy of damage functions) and other variables. Catastrophe modelling firms will often release updates to models after significant (or unexpected) events, such as the 2013 flash flooding in Calgary and Toronto (Canada) (Boyle, 2015). However, among the (developed and developing) countries that responded to an OECD survey on the financial management of flood risk, only about one-third indicated that data on past insured flood losses was available. The limited availability of data on past losses has been cited as a limiting factor in the robustness of models in a number of European countries (Boyle, 2015).

In countries where detailed topographical data and catastrophe models do not exist, information on past events can provide an (imperfect) source of information for understanding flood exposure. Broad use of technology by those affected could potentially be used to "crowd-source" data on flood impacts in order to develop initial maps of potential flood exposure (MacClune et al. 2015).

As in the case of mitigation investments, there may be some benefit in coordinating investment in mapping with the needs of the insurance sector for risk information. The efforts to develop quality forward-looking flood maps in Portugal was partly driven by the need to address low insurance penetration rates by providing insurance companies with a basis for pricing flood risk. As noted, the prioritisation exercise for flood mapping in Australia also explicitly considers the needs of end-users of hazard maps, such as the insurance sector.

4.3 Addressing limited demand for flood insurance

As outlined in Chapter 3, a number of factors combine to reduce households' and businesses' willingness-to-pay for flood insurance coverage, including the tendency towards underestimation of risk, misunderstandings about coverage and expectations of post-disaster compensation or financial assistance. The following sections describe possible approaches to enhancing the willingness-to-pay for flood insurance, including efforts to enhance public awareness of flood risk and the need for financial protection against such risks as well as ways to reduce the negative impact of *ex post* government compensation on willingness-to-pay for insurance coverage. This is followed by a

discussion of the roles of premium subsidies and various forms of compulsion and bundling of insurance coverage in addressing underinsurance of flood risk.

Enhancing public awareness

Building understanding of risk levels

There are a number of opportunities to enhance public awareness of the level of risk from flooding, ranging from making information on flood risk widely available to disclosure requirements related to property transfer or rental, to the use of price signals in setting insurance premiums. Almost all countries make information on flood risk publicly available. More than two-thirds of countries that responded to an OECD survey indicated that flood hazard maps are made publicly available and that various types of awareness campaigns are implemented to enhance understanding of flood risk. For example, in Japan, the Flood Control Act requires municipalities to distribute relevant information on flood risk to residents. In the United States, the FloodSmart program provides information on flooding and flood risk. In the United Kingdom, the "What's in your backyard" application allows users to access flood risk (and other environmental) information at the post code level. In France, a major public awareness campaign surrounded a major flood exercise for a 1-in-100 year flood affecting the Paris region, including videos of the potential impacts of flooding on various Paris landmarks. In Australia, a National Flood Risk Information Project has been implemented to improve the quality, availability and accessibility of flood risk information, flood hazard data and flood-related imagery (including from past events). However, concerns about liability related to the accuracy of flood risk information have led to some reluctance to publishing all relevant information (similar to the liability concerns related to land-use planning, see Box 4.2) (The Australian Government the Treasury, 2011).

A significant opportunity to build awareness arises at the time of purchase or rental of a residence and, in some countries, information on flood (and other hazards) at the level of individual properties is communicated at that time. For example, in France, sellers and landlords are required to provide information on any compensation that has been paid in relation to the property as a result of a natural (or technological) disaster and the risk of flooding must be disclosed as part of the home purchase process. Such information is also available in Australia (as "vendor statements") with some states (e.g. Victoria) deemed to be providing a robust system of disclosure of flood and other natural hazard risks (Productivity Commission, 2014). In other countries, property-level risk information is available but is not automatically disclosed upon property transfer or rental. In New Zealand, a Land Information Memoranda that provides information on natural hazard risks associated with a property or structure is available from the local council to any party upon request and payment of a fee. In England and Wales, the Environment Agency and Natural Resources Wales can provide households with a detailed flood map or a letter setting out the flood risk from rivers and the sea for the area of their property which can be used for the purposes of securing insurance coverage (DEFRA, 2013).

There is some evidence that public awareness levels will be affected by the approach taken to communicating risk. For example, a 1-in-5 chance of a flood over 25 years has been demonstrated to be taken more seriously than a 1-in-100 chance of a flood on an annual basis, even though the two describe similar levels of risk (0.8% annual probability vs. 1.0% annual probability) (Kunreuther and Weber, 2014). The use of return period probability measures (i.e. 1 in a given number of years) may give some the mistaken impression after an event that they will be safe from flooding for the remainder of the

return period (GAO, 2014). There is also a general tendency to assume that the actual occurrence of the event will occur near the end of the return period which suggests that using return periods within the lifespan (or normal property ownership period) of an individual homeowner may be more effective (Henrich, McClure and Crozier, 2015). The use of descriptions of impact, such as potential number of deaths, amount of damage, etc., can also improve the effectiveness of risk communication as there is some evidence that homeowners also tend to underestimate the potential impact of a flood. For example, a survey of New York City residents found that only about one-third of respondents had a relatively accurate perception of their probable flood damage and that more people tend to underestimate than overestimate the level of flood damage that they could face (47% underestimate and 19% overestimate) (Botzen, Kunreuther and Michel-Kerjan, 2015).

Experience with flooding has also been shown to play a significant role in decisions to purchase insurance coverage (or implement risk reduction measures) (see Box 4.8) which suggests that there might be some advantages to using risk communication approaches that are based on past events.

Box 4.8. **The benefit of flood experience for risk reduction and financial protection**

In many countries, the actual experience of being impacted by a flood event has often been a significant driver of the demand for flood insurance (while a lack of experience with an event may lead households to not renew their coverage). A systematic analysis of flood insurance take-up rates in the United States found an increase in take-up rates of 9% in areas affected by a presidentially-declared (flood) disaster, followed by a return to "normal" levels over a period of approximately 9 years (Gallagher, 2014). Similarly, a study of homeowners on the US Atlantic Coast found that those that had experienced previous hurricane damage were more likely to seek hurricane and flood insurance (Hudson et al., 2014). Substantial increases in insurance coverage for flood risk have also occurred after flooding in Germany and Australia (Swiss Re, 2012) and the 2005 hurricane season in the United States (Michel-Kerjan, 2010).

This suggests that (large) flood events may offer an opportunity for enhancing the effectiveness of public awareness campaigns. In Germany, the experience of local flooding in 2000 combined with a dedicated advertising campaign was effective in increasing flood insurance take-up rates more broadly. The study of post-event take-up rates in the United States also found an increase in take-up rates of 3% in neighbouring communities that weren't directly affected by flooding and in communities that were part of the same media market and therefore exposed to similar information on the floods (even where the communities with a shared media market were geographically distant and dissimilar to the affected community) (Gallagher, 2014).

Source: Gallagher, 2014; Hudson et al., 2014; Swiss Re, 2012; Michel-Kerjan, 2010.

A key challenge is communicating risk to households and businesses facing relatively lower-risk of flooding. For example, the demarcation of flood zones with more frequent return periods (e.g. 1-in-100 year SFHAs in the United States) may give the impression to those outside such zones that they face no flood risk at all. Similarly, the construction of flood protection barriers may give those within the zone of protection an unwarranted sense of being completely protected against any future flood risk.

Insurance premiums that are risk-based can also offer an important signal on the level of risk faced by individual households or businesses. Countries with flat-rate pricing of insurance premiums or public (re)insurance backing for high-risk properties (where invisible to the policyholder) do not communicate risk levels to policyholders (Surminski and Eldridge, 2014). Risk-based premiums are also important for ensuring that property-level risk information is transmitted through property values. A property facing significant flood risk and high insurance premiums should also have a lower resale value (all else equal). While this is difficult to measure (given the multitude of factors that affect house prices), a study in the United States found some evidence of price differentials for properties due to different levels of flood risk, particularly in periods after the occurrence of an event in the given community (with a decline in that differential over time) (Bin and Landry, 2013). Mandatory property-level risk disclosure could be a means of maintaining risk awareness in the years following an event. For example, a study on the impact of the 1998 California Natural Hazard Disclosure Law, which requires sellers of properties to disclose whether properties are located in SFHAs (among other natural hazard zones), found evidence that the law created a price differential of -4.2% for houses located in an SFHA (Troy and Romm, 2004).

Improving understanding of financial protection

In addition to enhancing household and business understanding of flood risk, many countries also invest in enhancing awareness of the need for financial protection. Just under one-half of surveyed countries indicated that information on financial protection options, such as insurance, are included in public awareness initiatives related to flood risk. In some countries (e.g. Czech Republic), a lack of financial education related to the protection that insurance can provide is seen as a significant cause of underinsurance given that awareness of flood risk (especially as a result of recent experience) is high. In the United Kingdom, a guide to obtaining flood insurance in high-risk areas was developed in collaboration with the National Flood Forum, the insurance industry and others (DEFRA, 2012). In the United States, FEMA's FloodSmart program provides information to the public on the benefits of purchasing flood insurance.

Where flood coverage is an optional add-on, there may be misperceptions among consumers about the level of flood insurance coverage included in their home, commercial, contents and/or business interruption policies. In Italy, for example, 42% of respondents to a survey believed (wrongly) that they were insured against damage from natural catastrophes (Swiss Re, 2013). In Australia, a survey of homeowners found that 37% were unsure as to whether there building insurance covered damage from flooding, including 23% of those that lived in known flood risk zones (Quantum Market Research, 2013). Based on the experience of the 2011 Queensland flooding, the Australian government has imposed new regulatory requirements to ensure that a standard definition of 'flood' is used in home building, home contents, small business and strata title (i.e. commonly-owned areas in residential buildings) insurance policies, and to require insurers to provide consumers with one-page fact sheets that set out key information about the coverage provided under home building and home contents insurance policies (OECD, 2015a).

How an optional flood coverage is offered to policyholders (i.e. opt-in vs. opt-out) can also have important implications for the level of take-up of flood coverage. Individuals tend to have a bias towards the default option when offered different options and there are a number of examples from other fields where differences in the default option offered result in differences in take-up rates (e.g. rates of organ donation in

countries where organ donation is automatic upon death are much higher than in countries where organ donation requires *ex-ante* consent (Johnson and Goldstein, 2003) as are rates of enrolment in defined contribution pension plans that use auto-enrolment (OECD, 2013b)). In Japan, the insurance industry instituted such a practice by specifically confirming a customer's decision not to extend their coverage to include protection against earthquakes as a means of reducing the potential for misunderstandings of the level of financial protection (Orie and Stahel, 2013).

The automatic renewal of insurance coverage (as in Germany) or the offering of flood insurance coverage as a multi-year contract could have a similar effect by making the maintenance of coverage over a number of years the default option (National Research Council, 2015). A survey in the Netherlands found that individuals might even have a higher willingness-to-pay for multi-year contracts relative to annual contracts (Botzen, de Boer and Terpstra, 2013) (although such contracts will usually be more costly than an annual contract due to uncertainty related to potential changes in risk or reinsurance market conditions and are prohibited in some countries, such as Germany, for contracts longer than three years).

In addition to improving the understanding of financial protection (and facilitating its purchase), some countries identified a specific need to raise the public's awareness of their responsibility for protecting themselves against flood risk. The expectation of government assistance can reduce the incentive for seeking financial protection as a costless alternative to the protection provided through insurance coverage. This impact can be somewhat mitigated by limiting the amount of financial assistance to small amounts or by only providing compensation for losses that are truly uninsurable. Lump-sum payments made irrespective of insurance coverage would also limit the impact of financial assistance on demand for insurance coverage (Schwarze et al., 2011).

However, even where the amount of government financial assistance available is limited, the perception that large amounts of government funding might be available could lead to misunderstandings about the need for financial protection. The publicity surrounding major flood events and the substantial public funding dedicated to recovery and reconstruction could give the impression that significant funding is available to affected households or businesses, when in reality most of the funding will usually be allocated to the reconstruction of public infrastructure. High ceilings on potential financial assistance, even when rarely reached, can also exacerbate misperceptions about access to public compensation. In the United States, FEMA's Individual Assistance program can provide up to USD 31 500 per household although the average grant size is USD 4 000 (Kunreuther and Michel-Kerjan, 2013) (large amounts are also available to households and businesses from the US Small Business Administration although that assistance is provided only as a loan (GAO, 2014)).

In most countries, the level of post-disaster government assistance that might be provided to an affected household or individual depends on a number of factors and is difficult to estimate in advance. In Germany, for example, government assistance is not based on formal legislation and therefore the granting of such assistance may not happen by default (Thieken et al., 2006). In the Netherlands, a statutory compensation mechanism has been established but there are no predefined rules on eligibility for – or level of – compensation (Surminski et al., 2014). In Russia, the government is legally obligated to provide assistance after a disaster although the amount of such assistance is only determined after the event. In many countries, government assistance is only available where there is a government declaration of a disaster which may not occur in the case of

smaller floods. Even in countries where specific programmes and eligibility criteria have been established for post-disaster assistance, the implementation of those programmes may be inconsistent. For example, the Australian Productivity Commission inquiry on natural disaster funding arrangements found instances of inconsistent application of the Australian Government Disaster Recovery Payment based on different applications of the eligibility criteria across different disasters (Productivity Commission, 2014).

There may be advantages in attempting to provide greater clarity on the amount of assistance likely available post-disaster as well as the conditions for accessing such assistance as a means of addressing these types of misperceptions (although this will create moral hazard if the assistance is not limited to uninsurable losses). A financial decision support tool that compares the compensation that would be available through insurance relative to government assistance could provide households with a means to more accurately assess their financial protection options (National Research Council, 2015).

Premium Subsidies

Enhancing understanding of flood risk and financial protection may not be sufficient in increasing coverage where premiums are unaffordable. In such cases, the provision of subsidies may be an option for ensuring that households (and potentially, businesses) are protected against flood risk – although, as outlined below, the use of premium subsidies can be expensive, difficult to remove, are likely to exacerbate moral hazard and have limited (or no) impact in terms of reducing the level of risk.

Premium subsidies can be effective in terms of increasing coverage. While demand for flood insurance coverage has been found to generally be price inelastic (National Research Council, 2015), studies have found a positive correlation between income and the amount of insurance purchased. In the United States, for example, income was found to be positively correlated to the amount of flood insurance purchased (Browne and Hoyt, 2000), while the purchase of optional insurance for contents in the United Kingdom has been found to be positively correlated with income (DEFRA, 2013). In a survey of insurance customer preferences across 30 countries, value for money was deemed to be the most important factor in decisions to purchase non-life insurance coverage while cost was the factor most often-cited for ending non-life insurance coverage or switching providers (Ernst & Young, 2014).

A number of countries provide subsidies to support the affordability of flood insurance, including both direct premium subsidies (explicit subsidies) for high-risk properties, cross-subsidies (or implicit subsidies) resulting from pricing that is not completely risk-based and tax exemptions related to the payment of premiums, either for consumers as expenses or insurers as revenues. In some countries, cross-subsidies have been the result of insurance sector practices, not specific government policy. In the United Kingdom, for example, until recently, insurers have generally (and voluntarily) charged similar amounts for home insurance with flood coverage to households facing very different levels of flood risk (DEFRA, 2013). In Japan, premiums for household coverage that includes flood are based on prefecture and building structure, regardless of the level of flood risk. In Chile, semi-flat premiums are charged for flood insurance coverage due to limitations in modelling that impede the establishment of true risk-based premiums. In other countries (France, Spain, Switzerland (for risks covered by the private sector)), cross-subsidies resulting from flat (or relatively flat)[1] pricing for flood (and other natural disaster) coverage is a deliberate government policy based on a principle of solidarity and sharing of risk across citizens.

Premium subsidies targeted to high-risk properties are provided in the United States and in the United Kingdom. In the United States, premium subsidies are provided for structures constructed before the completion of a Flood Insurance Rate Map (FIRM) for the given area (known as pre-FIRM structures) and for structures that have been re-zoned into a higher-risk area based on the completion of a new FIRM (grandfathered structures). The subsidies apply to the first USD 35 000 of coverage, with coverage for amounts above that threshold priced at full risk rates. On average, the property owners that benefit from such subsidies pay 35-40% of the full-risk rate for flood coverage (CBO, 2007). The subsidies (pre-FIRM and grandfathered) remain available if the property is sold although not after the property sustains substantial damage (a loss equivalent to 50% of the structure's market value) or if the property benefits from substantial improvement (leading to an increase of 50% or more in the structure's market value) (CBO, 2007). The subsidies are provided in the form of reduced premiums paid to the NFIP. Discounted rates are also available for properties outside of SFHAs with favourable loss histories (preferred risk policy) and for properties in communities that participate in Community Rating System (see Box 4.3). In the United Kingdom, premium subsidies are provided indirectly through the pricing of reinsurance for the flood portion of bundled household policies that is available through Flood Re. Flood Re offers standard prices for reinsurance coverage based on council tax valuation bands, no matter the level of flood risk. Insurers are free to set the premiums for the bundled coverage although the ability to transfer the flood risk component to Flood Re at a set price provides a notional ceiling on the premium rates for the flood component of household insurance coverage for high-risk properties (DEFRA, 2013; Flood Re, 2015).

Premium subsidies are not costless and can create significant contingent liabilities for public insurance schemes. In the United States, the cost of premiums subsidies is reflected in the significant losses that have been incurred by the NFIP after extreme events such as Hurricane Katrina in 2005 and Hurricane Sandy in 2012 (covered through borrowing from the US Treasury – see Chapter 5). These losses were incurred because the lower premium income resulting from subsidised coverage did not provide sufficient reserves to cover claims. In the United Kingdom, the costs have been incurred by low-risk policyholders that provided an estimated GBP 150 million in annual benefits to the approximately 250 000 households facing significant flood risk by paying higher premiums than their level of flood risk would require (DEFRA, 2013). Under Flood Re, the subsidy costs will be borne by the insurance industry (and their customers). Cross-subsidies, on the other hand, will not lead to direct costs if the overall level of premium income is sufficient to meet the cost of claims.

Premium subsidies (both those targeted to specific policyholders and cross-subsidies resulting from flat pricing) dampen the risk signal inherent in risk-based premium pricing and may therefore reduce (or eliminate) the policyholders' incentive for making investments in risk reduction. To avoid misperceptions about the level of risk as a result of such subsidies, it is important to ensure that policyholders are aware that the premiums they pay do not reflect the full level of risk that they face from flooding. In the United Kingdom, Flood Re has made an agreement with cedant insurers to pass information on the level of flood risk to their customers that benefit from Flood Re coverage. Where subsidies eliminate or reduce impediments to insurance affordability and availability, they may also reduce the incentives for mitigation or land-use controls at the level of local administrations (Douglas, Bowditch and Ni, 2013) (although this can potentially be mitigated by effective restrictions on land-use in flood zones and robust building codes).

A key consideration (beyond cost) is the impact of the subsidies on overall levels of financial protection. As noted, there is some evidence that subsidies are effective in increasing the demand for flood insurance. A study of demand for flood insurance among coastal households in the United States found evidence of higher demand for flood insurance coverage (and greater price elasticity of demand) from households that benefit from explicit premium subsidies (Landry and Jahan-Parvar, 2011). The proposal to eliminate subsidies under the *Biggert–Waters Flood Insurance Reform Act of 2012* coincided with a decline in policies in force in most US states, particularly among discounted pre-FIRM policies whose rates had risen with the implementation of the Act (Kousky and Shabman, 2015). Cross-subsidies that lead to higher premiums for low-risk policyholders could lead to reduced demand for coverage among low-risk households (Douglas, Bowditch and Ni, 2013) although that will likely depend on the cost per household of the cross-subsidies as well as the level of awareness that such cross-subsidies are being provided. In large policyholder communities, the cost per household would likely be low. For example, in the United Kingdom, the industry has estimated the cross-subsidy to be GBP 8-9 per year, per low-risk household on building and contents coverage (DEFRA, 2013).

The design of any premium subsidy programme will be important for controlling costs and ensuring that incentives for risk reduction are maintained (to the extent possible). Some considerations include:

- Subsidies should be means-tested to ensure that the benefits accrue to those most in need. To achieve this, a definition of affordability could be established with only those facing premiums beyond the affordability threshold benefiting from the programme. Such a threshold could be based on premium as a share of income or property value or some measure based on overall housing costs (including flood premiums) as a share of income (National Research Council, 2013).

- The scope of the programme could be limited to residential property only or only to those that are required to purchase insurance coverage (for example, as a condition of their mortgage financing). Neither the United States nor United Kingdom provide subsidies for high-risk commercial property.

- Costs could also be reduced by designing the programme to incur the cost of the subsidy upon the occurrence of the event (Allianz Australia Insurance Ltd., 2011), rather than at the time of the purchase of the policy. This is the case in the United States and United Kingdom as well as France, Spain and Switzerland as any costs related to subsidisation of premiums are only incurred when premium income is insufficient to meet claims. Another approach could be to provide support for the policyholder deductible, which would allow policyholders to choose higher deductibles (and therefore reduced premiums) and incur costs only upon the occurrence of an event. However, both of these approaches lead to uncertain contingent liabilities for government that will need to be appropriately managed (see Chapter 5).

- Another potential means to contain the costs of subsidies would be to limit the benefit of any subsidy to existing property owners (i.e. no subsidy would be available if ownership of the property is transferred). This could potentially impact the sale value of properties that benefit from the subsidy (although this could be seen as an appropriate correction to prices inflated by artificially low insurance premiums). Consideration should also be given to limiting subsidies to existing properties (i.e. not new developments) which recognises that some communities were built before the true level

of flood risk was known while ensuring that the availability of subsidies does not provide an incentive for developing risky areas.

- Investments in risk reduction could be required as a prerequisite to receiving the premium subsidy to counteract the impact of subsidies on a property owner's incentive to reduce their exposure. Similar to communities, financing for such investments should be available based on the expected reduction in insurance premiums that result (and could be provided through a public sector loan). Means-tested vouchers could also be provided to households that make risk reduction investments tied to the expected savings in risk-based premiums that will result from such investments (Kousky and Kunreuther, 2014). Mitigation loans could be attached to the property/mortgage (rather than the owner) to avoid complications related to ownership transfer (Knowles and Kunreuther, 2014).

- The premium subsidies could be funded (in full or in part) by local governments in order to provide an incentive for local communities (that usually make decisions on land-use and protective infrastructure) to reduce risk at the community-level (Allianz Australia Insurance Ltd., 2011; National Research Council, 2015). However, this would be less effective in older communities with legacy exposures to flood risk that are difficult to reduce.

In countries where national or local taxes are imposed on premiums for flood insurance (or insurance coverage more generally), consideration should be given to whether the imposition of such taxes impacts insurance affordability and is worth maintaining for all (or subsidised) properties. In Australia, for example, premium taxes have been estimated to increase premiums by 44% for home insurance and, based on modelling, may be responsible for close to 70 000 households choosing not to secure home insurance coverage (Barker and Tooth, 2008). Allowing insurers to accumulate tax deductible reserves could also potentially increase affordability by reducing the cost of insurance coverage.

The establishment of a public insurance scheme itself is a means of subsidising or supporting premium costs, depending on the structure of the scheme and rates charged. Public schemes can promote affordability by charging lower than actuarially-based premiums and also by passing on any cost-savings resulting from their status as a public entity, such as lower financing costs, limited marketing costs, tax savings as a result of income tax and/or premium tax exemptions as well as the underwriting profits and return on capital normally required by a private insurer. The scope of these cost savings could be significant. For example, in the United States, income taxes and the cost of capital have been estimated to account for approximately 20% of premiums (Property Casualty Insurers Association of America, 2011). In Australia, taxes and underwriting profits have been estimated to account for 17-33% of premiums (Douglas, Bowditch and Ni, 2013). A study of insurance premiums in three regions of Switzerland, Austria and Germany facing similar levels of flood risk found that the monopoly public insurer in Switzerland was able to offer premiums at rates of about one-third of premiums charged in the other regions (although insurance is also mandatory in that region of Switzerland which allows for the establishment of a broader risk pool) (Schwarze et al., 2011). However, these costs savings need to be considered in the context of any increase in operational costs involved in operating a public scheme relative to the operating cost of private insurers (see Chapter 5) as well as the costs to governments in terms of foregone tax revenue (where a public insurer is tax exempt).

Once provided, subsidies are extremely difficult to eliminate. In the United Kingdom, the elimination of cross-subsidies would lead to an estimated 200 000 households facing increases in premiums of 2% or more of household income (Flood Re aims to eliminate subsidies over 20-25 years) (DEFRA, 2013). In the United States, the *Biggert-Waters Flood Insurance Reform Act of 2012* reformed the NFIP to eliminate, over time, subsidised rates for certain policies, which would have led to significant long-term premium increases in a number of communities. For example, flood insurance rates for some properties in Hawaii, Georgia, Louisiana, and other states were reportedly set to increase from USD 600 annually to USD 20 000 - 50 000 (Nance, 2015). However, before these reforms could be fully implemented, the *Homeowner Flood Insurance Affordability Act of 2014* was enacted, which delayed, and in some cases eliminated, many of the rate reforms under the *Biggert-Waters Flood Insurance Reform Act of 2012* (see Box 4.9).

Box 4.9. **Reform of premium subsidies in the United States**

In an effort to address some of the challenges related to the NFIP, including the significant deficits created by Hurricanes Katrina and Sandy, the US Congress passed the *Biggert–Waters Flood Insurance Reform Act of 2012*. The Act required the elimination of subsidised flood insurance premiums over a transition phase through:

- the phase-out of all subsidised premiums for businesses and non-primary residences over 4 years;
- the phase-out of all subsidised premiums for all repetitive loss properties over 4 years;
- the phase-out of all subsidised premiums for "grandfathered" properties over 5 years (i.e. properties that were re-zoned into a higher-risk area based on the completion of a new FIRM);
- the elimination of access to subsidised premiums for any new purchases, new policies, property transfers, policy lapses or new repetitive loss; and
- the phase-out of all remaining subsidised premiums, including primary residences, beginning in 2014.

In response to the new requirements, a Coalition for Sustainable Flood Insurance was formed with the support of communities from 35 US states which lobbied the federal government to reverse the requirements. In 2014, the US Congress passed the *Homeowner Flood Insurance Affordability Act of 2014* which delays – but does not halt - the implementation of the *Biggert-Waters Flood Insurance Reform Act of 2012* by repealing some clauses and establishing new subsidies for some types of policies. The *Homeowner Flood Insurance Affordability Act of 2014* reinstated premium subsidies for grandfathered properties (i.e. properties that have been re-zoned into an SFHA) and will continue to allow property owners re-zoned into SFHAs in the future to have their rates grandfathered. Premium subsidies for pre-FIRM structures, on the other hand, will continue to be phased out (National Academies of Sciences, Engineering, and Medicine, 2015).

Source: National Academies of Sciences, Engineering, and Medicine, 2015.

The opportunity cost of premium subsidies, which are recurring and have limited (or no) benefit in terms of reducing risk, needs to be evaluated against the alternative use of those funds for investing in risk reduction. As noted above, investments in property-level

risk reduction such as property elevation, while capital intensive up-front, can lead to reductions in premiums that more than offset the cost of financing the initial investment. Consideration should be given to whether subsidies for risk reduction would be a more efficient use of public funds than premium subsidies. The establishment of programs to encourage household risk reduction (information on risk reduction options as well as grants and loans) could be one means to facilitate a transition away from subsidised premiums (Association of Floodplain Managers, Inc., 2013).

Compulsion

Other approaches to ensuring sufficient financial protection among households and/or businesses relate to making insurance coverage against flood risk mandatory or tying requirements related to insurance coverage for flood risk to mortgages, government compensation or other assistance or to home insurance coverage more generally (i.e. automatic extension of home insurance policies to include flood risk or bundling of flood insurance with home insurance).

There are three main types of insurance compulsion: mandatory purchase, automatic extension and mandatory offer (see Table 4.1).

There are a few countries that impose mandatory insurance requirements. In Iceland and most (22 of 26) Swiss cantons, insurance coverage of flood (and other disaster risks) is mandatory for all residential and commercial buildings. These requirements have been successful in ensuring broad financial protection against disaster risks as penetration rates are effectively 100%. However, in both cases, the requirements are complemented by extensive public intervention in the private insurance market through provision of direct insurance by the public sector and/or pricing regulation. In Iceland, the insurance coverage is provided by a public entity, Iceland Catastrophe Insurance (ICI), at a flat rate. In 19 of 23 Swiss cantons, (mandatory) insurance coverage for buildings is provided by a public cantonal monopole insurer with some limited risk pricing. In the other six cantons, the private sector provides the coverage for disaster risks although the pricing for that coverage is regulated and completely flat. Price regulation is necessary to eliminate opportunities for private companies to seek high profits in a market with mandatory demand. A pool has also been established by the private insurers to distribute disaster losses across insurers according to their market share in order to prevent the private insurers from only offering coverage for low-risk structures.

A mandatory insurance requirement with insurance provided by the public sector is economically similar to *ex post* government compensation for all losses (as in both cases, the costs are ultimately borne by taxpayers), although with some important differences. Public insurance offers the advantage of pre-funding those losses through the collection of premiums. While a dedicated general government reserve fund could be established, it would likely be more susceptible to being diverted to other uses (relative to the reserve fund of a public insurer). In some countries (e.g. France, United States), the accumulated reserves of the public insurer are also put to good use as a source of funding for prevention. A public insurer could also vary premiums based on risk and therefore provide incentives for risk reduction (Schwarze et al., 2011). On the other hand, where pricing is relatively flat, the overall cost for mandatory insurance will vary with the value of the structure/property which may be less equitable than *ex post* government compensation of losses that would be distributed across taxpayers based on income.

Table 4.1. **Types of insurance compulsion**

	Advantages	Disadvantages
Mandatory purchase	Promotes the expansion of disaster insurance coverage, and the diversity of risks covered, which should help to reduce insurance costs overall. Eliminates the risk of adverse selection (i.e. those who perceive themselves to not be at risk may not purchase insurance, possibly increasing risks in the pool). Addresses potential behavioural biases, which may otherwise lead to inadequate coverage. Serves to clarify the allocation of disaster costs and reduces the government's implicit contingent liabilities.	May be unpopular and perceived as a tax. May run contrary to the culture of the country and face constitutional constraints (e.g., limit to private autonomy). Enforcement of purchases may be difficult. Given the captive market, the insurance sector may seek to build strong profit margins into premium rates; at the other extreme, inadequate pricing may lead to underwriting losses and drain capital from the industry. Mandated pricing may become overly influenced by other policy objectives.
Automatic extension i.e., automatic inclusion of disaster coverage in basic voluntary property insurance policies	Can be effective if the penetration rate of the underlying basic policies is relatively high, so that they are used as a vehicle to spread disaster insurance coverage. Compared with the mandatory purchase of disaster insurance, this option entails a lower degree of compulsion and may be less unpopular.	May have negative effects on the market for the basic property policy to which the mandatory disaster extension applies if the extension leads to higher premiums or the exit of some insurers that are unwilling to underwrite disaster risk.
Mandatory offer	Promotes the expansion of disaster insurance coverage, so that businesses and individuals who are willing to purchase financial protection can do so.	May lead to adverse selection: those who perceive themselves to not be at risk may not purchase insurance, possibly increasing risks in the pool and leading to sub-optimal take-up rates; low risk awareness or cognitive biases may aggravate this effect. If the penetration rate remains very low, there may be inadequate risk pooling.

Source: Adapted from OECD (2012).

Such an approach may not be feasible in all countries. There may be public resistance to mandatory insurance requirements which could be perceived as a tax. There also may be constitutional impediments to mandatory insurance requirements in some countries. For example, in Germany, an infringement on personal autonomy, such as the imposition of an insurance requirement, is only permissible where that infringement is in the public interest and is appropriate and proportionate (i.e. there is no less intrusive way to achieve the same outcome) (Schwarze and Wagner, 2007).

Mandatory automatic extension of insurance policies to include coverage of disaster risks is more common. In France, insurance coverage for disaster risks is provided based on a mandatory surcharge applied to all home, commercial (including business interruption) and motor vehicle insurance policies. Insurers may choose to maintain the full disaster exposure covered by the surcharge or transfer it to a public (re)insurer or private reinsurance markets with the transfer of risk to the public reinsurer (*Caisse centrale de reassurance (CCR*) limited to 50% of the exposure. In Spain, coverage for extraordinary risks is mandatorily included in property, life and personal accident policies (and subject to a mandatory surcharge) and may be transferred in full to the *Consorcio de Compensación de Seguros* (CCS), a public entity, or retained in full by the private company. In Belgium, mandatory extension of insurance coverage to most disaster risks is also a requirement. These approaches have been successful in achieving high rates of penetration of flood coverage (approximately 75% in Spain, above 75% in Belgium, and 97% in France, for residential properties) although they are dependent on high-levels of property insurance coverage (upon which the extension is added). They also benefit from the creation of a broad pool of low and high-risk properties as well as diversification across different perils.

In countries where flood risk is not generally covered at present, mandating a new requirement could lead some companies to exit the home insurance market altogether rather than attempt to build capacity for underwriting flood risk. It could also lead to reduced competition in standard property insurance markets for properties in high flood risk areas as insurers may choose not to provide any property coverage in these areas if they are also forced to provide coverage for flood risk. While there would be expected benefits to the private sector from mandatory insurance requirements (in terms of creating/stimulating demand), there could also be resistance if the private insurers are forced to provide coverage for flood risks for all properties (including those considered uninsurable). Mandatory extension of insurance policies to cover disaster risks, where it leads to higher premiums, may also affect the demand for home insurance policies more generally. In Belgium, a public institution, *Bureau de tarification – Catastrophes naturelles*, has been established to arrange premium rates and contractual conditions for natural disaster risk policies that insurers refuse to cover under their own terms (or where the premiums that private insurers offer are unaffordable) (OECD, 2015a).

In a number of countries, including Austria, Latvia, Poland, Russia and Turkey, insurance coverage for flood risk is an automatic (although not mandatory) extension to most home insurance policies. In Austria, a limited amount of flood coverage is provided on a first-loss basis as part of standard home policies – additional coverage is available as an add-on. In Latvia, Poland, Russia, and Turkey, insurers are able to exclude flood damage from these policies where they deem the risk to be too high. In Latvia, the automatic extension of insurance policies to cover flood risk has achieved very high levels of penetration (95%) although levels of penetration in Austria, Russia and Turkey are much lower (less than 25%). Mandatory offer of flood coverage can also be beneficial in terms of ensuring awareness of flood risk and financial protection options, and can make an important contribution to increasing overall coverage levels (particularly where the offer is made on an opt-in basis, as discussed above). In the United Kingdom, the Gentleman's Agreement and Flood Re involve a commitment by insurers to offer flood coverage to all properties (built prior to 2009, as outlined above).

Where property insurance coverage is automatically extended to cover both wind and flood damage (for example, from a cyclone), the need for assessing the cause of damage – which can be challenging where structures are completely swept away – would be

eliminated, allowing for more efficient claims settlement. For example, Hurricane Katrina led to years of legal disputes over whether homes were taken away by wind or water (known as "slab lawsuits") (Sandink et al., 2010). This is the approach that is taken in France and Spain (where the mandatory extension of property insurance covers a number of disaster perils) and the approach proposed in a study on the establishment of a reinsurance pool to address insurance affordability in Northern Australia (The Australian Government the Treasury, 2015b).

In a number of countries, mortgage lenders will generally require flood coverage on the assets against which they are providing financing. In the Czech Republic and Portugal, this practice is perceived as a major driver of flood insurance penetration. In the United Kingdom, a requirement that flood insurance coverage be maintained for the duration of the mortgage in order to comply with the terms of the loan has been seen as key in achieving penetration rates of over 90% (DEFRA, 2013).

In the United States, there has been a statutory requirement for federally-regulated mortgage lenders to ensure that flood insurance coverage is in place for homes in SFHAs to which they lend. The requirements were tightened in 1994 after large floods on the Missouri and Mississippi rivers demonstrated the extent of continued underinsurance for flood risk (less than 20% of the flooded structures were insured) (Galloway, 1995). The 1994 changes included requirements that: i) coverage be maintained over the life of the loan; ii) flood insurance payments be escrowed where an escrow is required; iii) lenders obtain flood insurance coverage where borrowers do not (a recent proposal would clarify that lenders can charge homeowners for that insurance); and iv) failure to comply with the requirements could lead to fines imposed against lenders (National Research Council, 2015). However, an analysis of the NFIP insurance portfolio over 2000-2009 found that flood insurance policies tended to lapse after 2-4 years, including in SFHAs, despite the requirement for maintaining coverage over the life of the loan. As the average length of residence (7 years) is much longer than the average policy length (Michel-Kerjan, 2010), the causes likely include a general failure by lenders to verify coverage except at origination, the practice of transferring mortgages to other financial institutions or capital markets where verification of compliance with the flood insurance requirement would be unlikely to occur as well as limited fines imposed for non-compliance (Kunreuther and Michel-Kerjan, 2013). Lenders are also not required to monitor any change in the flood risk affecting a mortgaged property, for example, should a remapping lead to the inclusion of a property inside an SFHA (Huber, 2012). Beyond the enforcement challenges, the effectiveness of mortgage-linked requirements would also be limited in regions where mortgages on properties are less common. For example, an analysis in the United States of nine coastal counties found that only 39% of beach houses and 34% of properties located in the flood zone had mortgages (Landry and Jahan-Parvar, 2011),

In the United States, eligibility for public disaster assistance is also tied to insurance. For households in SFHAs, their communities must participate in the NFIP in order for them to be eligible for federal disaster assistance programs. Individual households that access these programs must also purchase flood insurance as a condition for receiving assistance. In addition, in South Carolina, policyholders seeking coverage through the state-backed wind pool are required to have federal flood insurance (Hartwig and Wilkinson, 2014).

In the United States, another form of compulsion has been proposed in the form of community-based flood insurance (a study of this option was mandated under the *Homeowner Flood Insurance Affordability Act of 2014*). A community-based flood

insurance option would involve issuing insurance coverage at the community-level with premiums funded by community members through a specific charge or through tax revenues. This approach has a number of potential advantages, including the establishment of a large pool of diversified risks (depending on the size of the community involved) and the creation of incentives for risk reduction at the community-level (where responsibility for land-use planning and flood protection investments often lies) through the possibility of lower premiums.

Note

1. In Switzerland, the premium rates charged by cantonal monopole insurers are partially cross-subsidising, although some structures may face premiums of three times the base rate or even up to a factor of 100 in rare cases (e.g. in one of the cantons: glasshouses and buildings with an extraordinarily bad loss experience may face premium rates of 40 per mill instead of 0.4 per mill of the sum insured).

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