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Role of Insurance in Reducing Flood Risk

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This paper considers the problems of flood risk management in the context of public and private insurance. It demonstrates the important role of insurance in reducing flood risk with examples from the U.K. and France. It includes a brief description of the summer 2007 floods in England.
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Introduction

Over 90 per cent of all deaths from natural disasters are water related,[1] and 99 per cent of deaths from flood from 1975 to 2001 (over 250,000 people) were from low-income groups. In richer countries, total disaster losses are generally less than 2 per cent of GDP, while in poorer countries the figure is nearly 14 per cent.

Architects have an important role to play in helping society to become more resilient[2] but so do insurance companies.[3] Some of the leading insurance companies have considered climate change adaptation very seriously,[4] especially following Hurricane Katrina. Summers will generally be drier with drought and subsidence problems, but there will still be extreme rainfall leading to flooding as was demonstrated in England in the summer of 2007. Winters will be wetter, again leading to more flooding. There is a growing realisation that civil engineering solutions are not enough. For flood management to be sustainable other, more natural flood management is needed. The insurance industry will have an increasingly important role in helping society to adapt and become more resilient.[5] Some ways in which insurers can help are:

1. Assistance with identifying areas at risk.
2. Catastrophe modelling.
3. Economic incentives to discourage construction in the flood plain.
4. Collection of data on the costs of flood damage to feed into benefit cost appraisals for flood management schemes.

* This paper reflects the author's personal views.
[1] United Nations (2004).
[2] Roaf *et al.* (2005).
[3] Crichton (2005a).
[4] Lloyds of London *et al.* (2006), Allianz *et al.* (2006).
[5] Crichton (2007a).

5. Promotion of resilient reinstatement techniques.
6. Promotion of temporary defence solutions.

The extent to which insurers can help society depends very much on how flood insurance cover is arranged and this varies depending on the country. It also depends on how sophisticated the country's insurers are in mapping flood risks and how much the insurers are regulated by government. The more the regulation, the less the insurers can use market forces to manage the risk.

How insurance operates around the world for residential properties

There are many different approaches to insurance in different countries around the world.[6] Where private flood insurance cover is available (and it is not available in all countries, for example Holland) such different approaches can be categorised into just two basic types, what Crichton[7] calls the "option" system and the "bundle" system.

The option system

Under this system, insurers agree to extend their policy to include flood on payment of an additional premium. This system can be found in Belgium, Germany and Italy for example, and in the North West Territories of Australia, but the take up rate is very low.

There are a number of problems with optional cover. Apart from the problems of defining what "a flood" means so it can be excluded, the biggest problem is adverse selection. Adverse selection means that insurers tend to select against customers by only making the cover available in areas they consider to be safe, while customers select against insurers by only buying it in areas they deem to be risky. The result is that cover, when it is available at all, is expensive, and has very low market penetration. Such insurance is unlikely to be sustainable because a big enough "book" of business cannot be achieved. In countries where the government will step in to compensate flood victims, this further reduces the effective demand for insurance.

The bundle system

In this system, cover for flood is only available if it is "bundled" with other perils, such as fire, storm, theft, earthquake, etc. This system is used in Britain, Japan, Israel, Portugal, and Spain, for example.

With the bundle system, insurers have the freedom to charge differential rates, but excessive rate increases can be mitigated because the risk is not only spread over time, but across perils, and across rating areas. People living in areas safe from flood still have to buy flood cover if they want to get earthquake cover, for example (as in Portugal), and vice versa. This system is characterised by much higher market

[6] Schoubroeck (1999).
[7] Crichton (2002).

penetration. Because everyone is paying for flood insurance whether they think they need it or not, this reduces the opportunities for adverse selection by customers.

State involvement in compensation for flood survivors

There are four categories of state involvement in compensation for flood survivors[8] and these are outlined below.

No state compensation for citizens although there may be grants for infrastructure repair (Argentina, Germany, Israel, Japan, Portugal, U.K.)

The lack of financial compensation can slow recovery, but it does encourage private insurance.

Procedures to provide compensation in hardship cases (Australia, Canada, Holland, and China)

The state may not be well geared up to assess how much compensation to pay or to administer it efficiently. Residential flood insurance is not generally available in these countries, although in Australia and Canada cover is available for floods caused by drainage or sewage overflows.

State reinsurance (Belgium, France, Italy, and Spain)

Here the cover is often based on individual private insurance policies and the state involvement is only for reinsurance and/or catastrophe situations. Sometimes state assistance for the survivors of a disaster may be dependent on the whim of a politician who could be influenced by many other issues, not always entirely objective.

In France, the CATNAT system has been running since 1982 under which the government acts as a reinsurer. There is also the Bernier Fund that provides loss reduction incentives. This is funded by a levy on insurance premiums, and according to Mr. Roland Nussbaum,[9] director of Mission des Risques Naturels, a body formed in 1999 to monitor and report on natural hazards, this causes some resentment because those who live in safe areas are in effect forced to pay for risk reduction measures for others. There is a complex relationship between insurers, the government reinsurer (Caisse Centrale), the state insurance commission, the state guarantee, and local authorities, which, according to Mr. Nussbaum, often leads to confusion and inertia.

National Flood Insurance Program (NFIP) in the U.S.A.

Here, some 95 private insurance companies provide the cover and claims handling service in almost all cases but pass the premium on to the government and recover the

[8] Crichton (forthcoming).
[9] Nussbaum (2004).

claims costs from the government. Premium is expensive and average take up is only around 50 per cent. Until Katrina, the scheme was self-funding with the U.S. Treasury giving a guarantee that claims would be paid. Annual claims costs never exceeded $2bn. Following Katrina, and with an estimated NFIP claims cost of $23bn, the scheme is under review.[10]

The effects of the variability and increasing uncertainty of climate change on flood risks

Within Europe, more than 10 million people live in areas at risk of extreme floods along the Rhine, and the potential damage from floods amounts to €165bn. Coastal areas are also at risk of flooding. The total value of economic assets located within 500 metres of the European coastline, including beaches, agricultural land and industrial facilities, is estimated at €500 to €1,000bn.[11] In Britain, reports from the "Foresight" programme of the Office of Science and Technology[12] show that the flood hazard in Britain will increase significantly in the next 100 years with the number of people at risk increasing from 1.6 million to between 2.3 and 3.6 million by 2080.

Drains and sewers in towns and cities could be particularly affected by climate change and increased flooding. Short duration rainfall events will become more severe, resulting in more flooding from drains and sewers. New European standards for urban drainage (EN 752) are based on flood frequency rather than rainfall return periods as in the past, and therefore drainage designs will in future have to take into account other factors such as pre-existing groundwater levels, or changes in urban runoff. Even so, the new standards only require drainage to cope with a 1-in-30-year event in urban areas, which is hardly adequate in the context of climate change. Lindholm[13] describes recent court cases in Norway, which have challenged this limit and allowed insurers to recover flood claim costs for drainage failure caused by events up to 1 in 100 years.

All mainstream scientists now agree that climate change is happening and the impacts will get worse. The latest projections of extreme events in Europe are detailed in a report[14] from an EU project called "the Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects" (PRUDENCE). The main conclusions are that by 2071–2100:

- Heatwaves will have increased in frequency, intensity and duration especially over the continental interior of Europe.
- Precipitation will show major changes. There will be heavier winter precipitation in central and northern Europe and decreases in the south. Heavy summer precipitation increases in NE Europe and decreases in the south are projected. The summer floods in England in 2007 are consistent with this (see below). Longer

[10] Dixon *et al.* (2006).
[11] European Commission (2004).
[12] Thorne *et al.* (2006).
[13] Lindholm *et al.* (2007).
[14] Beniston *et al.* (2006).

droughts will happen in Mediterranean countries, but there could still be severe rainstorms with faster runoff.

- Extreme wind speeds will increase between 45°N and 55°N except over and south of the Alps, and become more northwesterly. These changes are associated with reductions in mean sea level pressure and will generate more North Sea storms, leading to increases in storm surges along the North Sea coast, especially in Holland, Germany and Denmark.

Dronia[15] has suggested that winter storm tracks may move south: this would affect areas such as France where buildings may be less resilient than in Scotland or Scandinavia, as happened in 1999. Indeed, Alain Joly, director of research at the French national meteorological research centre has warned[16] of a 50 per cent increase in the number and severity of storms in France by 2080.

Sea levels are rising as sea water expands due to rises in temperature and as polar ice melts. With a rising sea level, tsunami events and storm surges will become more damaging. With a warming ocean, tropical storms are likely to increase in frequency and intensity. Such storms can frequently cross the Atlantic and end up in Europe. Shallow slope coastal areas are particularly vulnerable as storm surges are higher there and run up further. Hurricane Anatole in December 1999 created an unprecedented 5-metre storm surge on the west coast of Denmark, which resulted in coastal defences being overtopped or breached and thousands of properties damaged. Low lying coastal areas in the Gulf of Mexico suffered from storm surges in excess of 8 metres in 2005. Society will need to adapt urgently, but in England there seems to be more "maladaptation".[17]

The summer 2007 floods in England

In 2007, England and Wales had their wettest summer since records began in 1766. By 25 July the Met Office reported that 387.6 mm of rain had fallen already since the beginning of May. There was unusually severe rainfall on 25 June and 20–22 July.

The record downpour in June flooded 27,000 homes and 5,000 businesses in the Midlands, Yorkshire and Northern Ireland. Sheffield, Doncaster and Hull were particularly affected, because drainage systems could not cope, costing insurers an estimated £1.5bn. Hull was the worst affected.[18] Unfortunately in Hull the flood was made worse by the 80-year-old storm drainage system, which had not been cleaned and was blocked by tree roots, grass cuttings and leaves.

The rain in July resulted in rivers overflowing and flooding 10,000 homes in Gloucestershire, Oxfordshire, Warwickshire, Worcestershire and Bedfordshire. It is estimated that this event could have cost insurers a further £2bn.

Ironically a flood event can stimulate GDP owing to increased sales of replacement building materials and household goods and increased purchase of insurance, so the

[15] Dronia (1991).
[16] Joly (2004).
[17] Crichton (2007b).
[18] Crichton (2007c).

overall economic losses were not great. The human costs and suffering, however, were huge, even for people not actually flooded. The July 2007 flooding left at least 350,000 homes without running water and 50,000 without power. There were fears that a further 250,000 would lose power and water if Gloucester's Walham substation was flooded, and emergency crews with help from the army worked overnight to keep the floods out. Questions were subsequently raised over the wisdom of locating housing, electrical substations and water treatment plants in the flood plain.

These floods may well trigger further insurance premium increases in English floodplains and help to discourage people from living in such areas. However, it seems unlikely that the Government in England will learn the lessons of the summer floods of 2007.

Flood risk assessment and modelling

To be able to assess and manage risks, insurers need to understand the components of risk.

There are many different definitions of "risk" in use, but Crichton[19] has proposed one of the simplest and most comprehensive, which is now called the "Crichton Risk Triangle". With a changing society and climate, insurers can no longer rely solely on historical claims experience to predict risk. It is necessary to analyse each of the components of risk because they are each changing in different ways. Imagine an acute-angled triangle where the three sides are hazard, vulnerability and exposure. The area of the triangle represents the risk, so if any one of these components is missing, then there is no risk. Risk can be reduced by addressing all sides of the triangle, searching for the most cost-effective reduction measures. Each of these three elements is considered in more detail below (see Figure 1).

Flood hazard can be managed to some extent by building flood defences such as sea walls and river embankments. However, the power of Nature may overcome these especially as the hazard grows with climate change. Exposure is already growing as more people live near the coast or on floodplains, but this could be controlled by land-use planning. For economic, historic or logistical reasons building is still likely to grow in exposed locations. In the U.S.A., for example, it is clear that a growing number of people wish to live and build in southern coastal areas. Even in hazardous areas, risk can still be managed by reducing vulnerability. This may mean building in a more resilient way; for example, in Holland there is an increasing use of floating houses, while in London's Docklands area, the ground floor of apartment blocks is often reserved for car parking.

Deterministic modelling requires consideration of the values of each of the three sides of the triangle in given scenarios. Probabilistic modelling also requires an assessment of the probabilities of different frequencies and severity situations. To the layman, frequency and severity are usually associated with the hazard – how often it floods and how severe the floods are. However, the best models must recognise that exposure and vulnerability can also vary in frequency and severity. For example in

[19] Crichton (1999).

Figure 1. The Crichton risk triangle.

June 2005 there was a motorcycle rally near Boltby in North Yorkshire in England. Ten thousand intoxicated bikers slept that night in tents on the banks of the River Rye. The very next day, heavy rains caused a dam break and a flash flood that would have swept the campers away if they had still been there. Risk management must recognise that controlling exposure and vulnerability can be much more cost-effective than simply trying to control the hazard.

Hazard

Climate change will certainly increase the frequency and severity of flooding events but specific events are impossible to predict. Flood management policy has concentrated on dealing with the effects of flooding rather than the causes. Thus the answer has often been seen as "structural" solutions such as walls, drains and reservoirs.

Vulnerability

Different types of construction show different levels of vulnerability to flood or windstorm damage.[20] All the major insurers in Britain have pooled flood insurance claims data in what is now the biggest database of flood damages in the world, the British Flood Insurance Claims Database, held at the University of Dundee.[21] This enables insurers to model different flood event scenarios, and assess total maximum losses, as well as calculate insurance premiums. The data show the actual financial costs of a flood to insurers, rather than the theoretical economic losses. For example, if someone has a 20-year-old carpet, the economic loss is another 20-year-old carpet whereas U.K. insurers will generally provide cover on a "new for old" basis. There have been attempts to develop similar databases in Germany and Italy, but these are relatively small, localised, and under-funded. The database has demonstrated that if the property is likely to be flooded again, resilient reinstatement can often be cost justified.[22] Garvin has demonstrated[23] how flood damage can be reduced by using more resilient building materials.

[20] Crichton (2007a).
[21] Black and Evans (1999).
[22] Building Research Establishment (2003).
[23] Garvin *et al.* (2005).

Urban vulnerability has increased considerably in the last 100 years. A good example of this is Paris, a region of 11 million people, of whom 800,000 are directly at risk from floods, and 2 million who could suffer indirectly. Madame Merli,[24] when Préfète of Paris and the Ile de France area, has eloquently described the Paris floods of 1910 when the Seine rose 8 metres as 4 billion cubic metres of muddy, sewage-laden flood water flowed through the city. Mellot[25] has produced an excellent book of more than 300 photographs of the flood, showing how people were still able to get around the city thanks to horse-drawn carts and carriages. The 1910 Paris flood was a 100-year return period event but less severe flooding was common in Paris in the latter half of the 19th century with floods in 1854, 1856, 1861, 1866, 1872, 1876, 1882, and 1883. Since 1910, four reservoirs have been built to store flood water, and the people in Paris seemed to have forgotten about flood hazards, but these reservoirs can only cope with a rise of a few centimetres in river level, giving a false sense of security. As a result, Paris has become much more vulnerable compared with 1910. The Seine has been restricted in width, many new schools and hospitals have been built in the danger zone, 154 km of underground railway has been constructed, buses are now used instead of horse-drawn vehicles, and people are dependent on electrical power. There are now 600,000 underground car park spaces with basement depths up to 10 levels.

Exposure

Unlike perils such as windstorm or drought, property exposed to flood can be identified with reasonable confidence. It is usually specific to low lying topography and dependent on drainage effectiveness for example. Flood mapping is therefore the obvious solution to assessing exposure. In the U.K., concerns about possible adverse selection have caused a number of major insurers to invest substantial sums of money in better flood maps for their own use. Such research has been expensive, but commercial imperatives have meant that for several years, the leading insurers and reinsurers have been able to dynamically model various flood event scenarios to an increasing level of sophistication around the world. In the U.K., insurance penetration is so high that one insurer, for example, has spent £5 million just on digital elevation models produced using the latest airborne "synthetic aperture radar" technology surveys in order to be able to produce high resolution flood maps. As flood maps improve, there is increased scope for governments to avoid exposing their citizens to flood risk. They can for example use the planning system to prevent developments in flood hazard areas.

Planning systems in selected European countries

England

After a year of consultation that seems to have completely ignored representations from insurers, a new planning policy statement "PPS 25" for England was issued in

[24] Merli (2004).
[25] Mellot (2003).

December 2006.[26] The new statement, as with its predecessor, *Planning policy guidance* 25 (PPG 25), continues to permit development in flood plains in England if there is nowhere safer to build, using a "sequential rule" (similar to the one introduced by the European Union's Seveso Directive). Since 2000, a U.K. Government report[27] stated that 11 per cent of all new housing in England has been constructed in floodplains, often against the advice of the government's own Environment Agency. Kate Barker,[28] in a report for the U.K. government, calculates that over 2.3 million additional households will be needed in flood hazard areas such as Greater London, the South East and the East of England. There is no suggestion that people should be encouraged to relocate to safer areas and England is now the only part of the U.K. where flood plain development is still permitted.

It is argued that in England there are economic or logistical reasons for allowing floodplain development. Such arguments are often spurious, however, given the lack of data on:

- The true financial costs of flood events.
- The human costs of damage to physical or mental health from a flood event.
- The loss of income of people or businesses caused by a flood event.

Continued flood plain development in England is having an effect that does not yet seem to be appreciated by the English government. Property developers have realised that they cannot sell new houses to private buyers in floodplains because the buyer cannot get insurance and without insurance cannot get a mortgage. Instead, property developers are increasingly using flood plains for social rented housing for low-income families, homes for the elderly or disabled, schools and hospitals. Planning policy and insurance problems in England are leading to the creation of ghettos of the most vulnerable people in flood hazard areas. There are now over 2,000 schools and 80 hospitals in flood hazard areas in England. Small businesses have to follow their customers into such areas and are increasingly at risk.[29] These businesses are often important for social cohesion in deprived areas.

France

While the English guidelines are "flexible" about building in hazardous areas, the French system is becoming more coercive[30] with strong central government control. At present, the French use a system called Plan d'Occupation des Sols (POS), which is the basic land use planning documents, where the decisions are taken at commune level. In 2005, new hazard zoning regional maps, the Plan de Prévention des Risques (PPR), began to be introduced. These go beyond the POS with a zoning overlay for flood, subsidence and other hazards. They contain more mandatory input from the central government level and are meant to interface with the previous system. Local French

[26] DCLG (2006).
[27] House of Commons Communities and Local Government Committee (2006).
[28] Barker (2006).
[29] Crichton (2006a).
[30] Poittier *et al* (2005).

planners will in future be prevented by law from allowing development in any of the "red zones" of the maps. PPRs are fixed by law by the central government and will be difficult to change in the light of new information or local knowledge. There is a lack of local participation in drawing up these maps, which is creating resentment. The risk maps do not take flood defences into account, even if such defences increase the downstream hazard. Cost–benefit appraisals for flood defences were not introduced until 1999. The zoning maps are currently being rolled out to the 30,000 communes. The large number of players involved and transboundary issues between the different communes and their mayors create problems, although there is some attempt at cross boundary liaison with "Schemes of Coherent Territorial" (SCOT).

Germany

Germany is set to follow the coercive French approach, and currently flood risk maps are being prepared by consulting engineers for the whole country. The legislation is already in place to make the use of such maps compulsory when they have been prepared.

Ontario, Canada

After Hurricane Hazel in 1954, the planning authorities in Ontario instituted a strict policy for flood hazards.[31] Nothing could be built within the 250-year floodplain, except escape roads that had to be raised above flood level. Flood defence work ceased in those areas. New properties on the fringes of the zones were only allowed if the ground floor was kept unoccupied, for example for car parking. Existing properties in the hazard area could not be sold, other than to the municipal authorities, who would buy them at market rates and then demolish them. Fifty years later, the flood plain is largely parkland and woods, even in the centre of cities such as London, which is now called the "forest city" of Ontario.

Scotland and the "Insurance Template"

Scotland's position can be seen as representing a "third way" between the extremes in England and France.[32] In Scotland, different solutions have been found: close dialogue between councils and all key stakeholders, including the insurance industry in 19 local "Flood Liaison and Advice Groups" (FLAGs), has been going on since 1995. Almost all councils are involved, often working together on a catchment basis. This regular local consultation with stakeholders on all types of flood issues seems to be unique to Scotland and has produced remarkable results. For example, the spread of best practice on sustainable drainage systems alone has reduced flood risks. Councils are also very aware that allowing development in flood hazard areas could lead to insurability problems in the future. By July 2002, a survey by Amy

[31] Brick and Goldt (2001).
[32] Crichton (2005b).

Table 1 The insurance template[a]

Type of housing	*Return period (years)*
Sheltered housing, and homes for the disabled and elderly	1,000
Children's homes, boarding schools, hotels, hostels	750
Basement flats	750
Single storey homes without escape skylights	500
Ground floor flats	500
Flashy' catchments (little or no flood warning available)	500
Single storey homes with escape skylights	300
All other residential property	200

[a]Crichton (1998).
Return period up to the year 2050 in each case, taking climate change into account. © D. Crichton (1998).
Extract from the residential property section of the "insurance template".
Standard of protection that insurers are prepared to cover at normal terms.

Tavendale[33] at Leeds University showed that most Scottish Councils had accepted some or all of the elements of the "Insurance Template", an extract of which is shown in Table 1.

This template provides a national standard of acceptable levels of flood risk, by showing what levels of risk can be insured at normal terms, and this has produced a high level of consistency and definition in planning strategies across Scotland.

Sweden

Until the last decade, Sweden[34] had a period without any major flood problems, and insurance was widely available. In recent years, however, there have been some major flood events and the government and insurers are taking the issues very seriously.

- As in Scotland and Austria, hydropower is a major industry, and Sweden has come to realise that many of its towns are vulnerable not only to decisions made by the dam owners about how much water to release and when, but also to possible dam failure or emergency release of water to prevent failure as in Perth in 1993.[35]
- Again as in Scotland, Swedish local government is responsible for flood protection and building permits. However, a major difference is the legal position: local authorities are open to legal action from property owners and insurers to recover the costs of flood damage. The Swedish Supreme Court has held that local authorities can be held accountable for damage due to an unsuitable location if they grant a building permit. This means that the owners of flood damaged property or their insurers can seek compensation from the local authority in such circumstances. One indication of the effectiveness of this was that during the floods of 2000 in central Sweden, no structures with building permits issued after 1990 were damaged.

[33] Tavendale and Black (2003).
[34] Thorsteinsson *et al.* (2007).
[35] Smith (1993).

- As in Scotland, local planners express risk in terms of an acceptable event return period, but unlike Scotland, in Sweden this varies depending on the "social tolerance" of flooding expressed in terms of impact. Thus inner city areas with a high level of people at risk and a high level of investment have the lowest tolerance and merit priority.

The European Flood Directive (FD)

The EU now seeks to make it compulsory for all member countries to establish flood hazard maps along the lines of those being developed in France and Germany. This provision is described under a proposed Flood Directive.[36] The objective of this Directive is stated as: "…to reduce and manage flood-related risks to human health, the environment, infrastructure and property." It proposes "concerted action at Community level" and says, "The Water Framework Directive 2000/60/EC2 (WFD) introduced the principle of cross-border coordination within river basins, with the objective of achieving good quality for all waters, but it set no objective on flood risk management".

This is not strictly speaking correct as the WFD actually talks about "good ecological status" rather than "good water quality". Good ecological status would include levels of flow or lack of it, in other words flood or drought. It has been argued that there is no need for a separate flood directive. On the other hand, the WFD has already been used in England as a reason to prevent some non-structural flood management such as the modification of rivers and lakes to provide increased flood storage.

Sustainable flood management

There is now a move away from civil engineering solutions. Perhaps the leading country in civil engineering investment in flood defences was Japan. Takeuchi[37] has documented the high death tolls from floods in Japan, especially during the period 1945–1959, with more than 1,000 people killed every year and two of the floods each killing more than 5,000 people. The worst event in Japan was the Isewan Typhoon flood in 1959 that killed 6,000. The Japanese have now realised that they cannot defeat Nature with concrete and since 2001 their strategy has been to use more natural flood management such as restoring natural storage in the upper reaches of the catchment and restoring rivers to their natural state.

Within Europe there are an increasing number of examples of sustainable flood management, for example, restoring meanders in the Rhine to protect Holland. The SAFER project (Strategies and Actions for Flood Emergency Risk Management) involves a partnership of Germany, Ireland, Scotland and Switzerland, working on various sustainable flood management techniques and details are shown on their website (www.eu-safer.de). The charity WWF in Scotland, using funding from the

[36] European Parliament (2006).
[37] Takeuchi (2002).

HSBC Bank, has established a large demonstration site in central Scotland to assess the financial costs and benefits of sustainable flood management. In a recent report,[38] the WWF says it has found that sustainable flood management is 10 times more cost-effective than engineering solutions.

The "Human adjustment to floods" concept is based on Gilbert White's work[39] in the 1940s. The basic idea is to adjust the way humans live with floods by land use zoning, flood proof buildings, and flood insurance. The role of flood insurance is important in that it provides direct economic incentives to individuals to relocate or take their own precautions against flood while at the same time facilitating rapid economic recovery after a flood. In short, it seeks to address the causes of flooding instead of the effects:

- Instead of confining rivers within dykes and dams it is better to manage floods within the river basin as a whole.
- Instead of a "no floods" policy of inhabited areas, which is proving to be very expensive and not very effective, allow some floods in sacrificial areas but with measures to reduce their severity through land use planning and more resilient construction.

There are a number of problems with structural defences:

1. They can give a false sense of security as demonstrated in the New Orleans floods of 2005. An unofficial comment from a U.S. engineer was, "There are two types of levees. Those that have failed and those that will fail."
2. Flood defences can themselves be damaged by floods. The Japanese government calculated that after the Naka River and Kokubu River floods of 1998 and the Fukuoka floods of 1999, half of the costs of the floods consisted of repairing damage to the flood defences.
3. Structural flood defences need constant maintenance. The more numerous the defences, the greater the cost of maintenance, taking much needed public spending away from schools and hospitals and other essential services.
4. If a river is walled in and not allowed to flood onto the banks, it is more likely to deposit sediment in the bed of the river. This raises the height of the river, meaning that the walls have to be raised too.
5. Defences can simply displace the problem upstream or downstream. This is a particular problem in continental Europe where one country's flood management solution can be another country's increased problem.
6. When a flood defence fails, the results can be more catastrophic than if the defence had not been built at all because the failure can be sudden and more people may be in the danger zone.
7. Flood walls can act as a barrier to stop the flood draining back into the river or sea. After the 1953 coastal flood in England and Holland for example, many defences had to be demolished to let the water drain away.

[38] WWF (2007).
[39] White (1942).

Following representations and advice from the insurance industry and NGOs such as WWF, Scotland has made sustainable flood management the cornerstone of its strategy[40] for implementing the Water Framework Directive (the only EU member to do so). Sustainable flood management is defined in Scotland as follows: "Sustainable flood management provides the maximum possible social and economic resilience against flooding, by protecting and working with the environment, in a way which is fair and affordable both now and in the future." Resilience in turn is defined as: "the ability to recover quickly and easily".[41] The Scottish Executive strategy is to deliver Awareness + Avoidance + Alleviation + Assistance.

There is a growing awareness that floods can only be managed in a sustainable way by using more natural solutions, protecting and restoring natural systems and working with Nature instead of fighting it.

Conclusions and policy recommendations

> The task is not just to preserve water resources to sustain life, but also to reduce the capacity of water to take life away. …We can and must reduce the number and impact of disasters by building sustainable communities that have the long-term capacity to live with risk.
> Kofi Annan, United Nations Secretary-General (8 October 2003).

Climate change will significantly increase the frequency and severity of flooding. Measures to reduce greenhouse gas emissions are essential and urgent but global agreement is still far away. In the meantime individual countries can reduce their own climate change impacts by adaptation. Insurers have the ability to and perhaps the duty to play an increasingly important role in helping society to adapt.

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