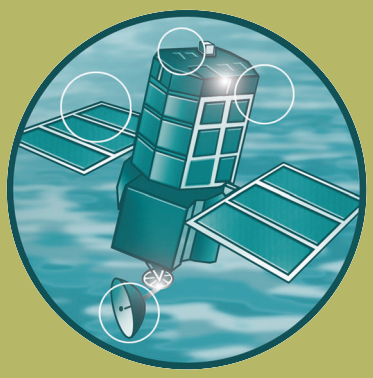
Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme

Developing the evidence base for flood resistance and resilience:

Summary Report

R&D Technical Report FD2607/TR1



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Developing the evidence base for flood resistance and resilience

R&D Summary Report FD2607/TR1

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1. Key findings

It is estimated that around 470,000 properties in England are currently located in areas subject to a significant (greater than 1.33% annual probability) risk of main river and/or coastal flooding (Environment Agency, 2006). This figure excludes properties which could be at a similar risk of flooding from minor rivers, surfacewater run-off and/or groundwater. Climate change is likely to increase the pressures on these properties and increase the need for the consideration of a wider portfolio of flood management approaches. This may include the greater use of flood resistance and resilience measures within individual properties. This study examines the cost effectiveness of using these measures to reduce the vulnerability of existing properties; considers the practical barriers to take-up and provides recommendations for increasing their future use.

The key findings of the research are:

- Measures designed to keep water out of the individual properties (resistance measures) are economically worthwhile for properties with an annual chance of flooding of 2% or above (50 year return period). The largest percentage savings are for residential properties with an annual risk of flooding of 4% or greater (25 year return period). For households that flood more than once in every ten years, the benefits outweigh the up-front investment by a factor of between five and ten, while for the average office-based business they outweigh the up-front investment by between six and eleven times.

- Temporary resistance measures (i.e. temporary flood guards and airbrick covers) reduce the costs of damage by about 50% if they are properly deployed prior to a flood. Additional investment in permanent resistance (i.e. permanent floodproof doors, windows and airbrick covers) increases the proportion of prevented damage to between 65% and 84%, but these measures are not as cost-beneficial as temporary resistance measures due to the higher investment costs.

- In contrast, a full package of resilience measures (i.e. the use of flood-resilient plaster, resilient kitchens and resilient flooring) will only be economically worthwhile when installed in a building that has a greater than 4% annual risk of flooding or that has a greater than 2% annual risk and is in need of repair or refurbishment. In the latter case, the extra cost of resilience is relatively low. Building in resilience without the driver of refurbishment or repair was not found to be desirable.

- However, householders' and businesses' perceptions of the benefits and costs of these measures are influenced by a range of other factors not included in the economic analysis (above). These include the payment of VAT for the purchase of products, a tendency to discount future benefits more heavily and the responsiveness of insurance terms to the particular risk circumstances of individual properties. Sensitivity analysis suggested that, of these factors, insurance is the most influential. Where insurance terms accurately reflect the flood risk, measures are equally as cost-

beneficial from the individual's point of view as they are from the societal point of view (i.e. beneficial for properties subjected to an annual risk of flooding of 4% or greater), but where they do not, resistance and resilience measures only become cost-beneficial to the individual householder or business at a 10% annual risk of flooding.

- A telephone based survey of 1,131 individuals showed that many householders and small businesses in areas of significant flood risk recognise the benefits of property-level measures, including the potential long-term financial savings, greater feelings of safety and reductions in the disruption caused by floods.

- However, the survey also showed that many people are deterred from taking action because they feel they are expensive or not their responsibility. Householders and small businesses also identified a wide range of other factors that deter people from protecting their properties, including not knowing the right property-level measures to use, concerns about impacts on the appearance of the property, not wishing to be reminded of the risk, and concern that such measures might adversely affect property values or make them hard to sell.

- The resistance/resilience measure of which households and businesses were most aware was the sandbag (Businesses – 33% flooded, 54% non-flooded; Households – 36% flooded, 60% non-flooded). This is in spite of the fact that most flood management experts consider sandbags to be a largely ineffective resistance technique. In addition, less than one in four surveyed were able to recall any resistance measures other than sandbags and only one in ten could think of an example of a resilience measure.

- Flooded households in the survey were much more likely than un-flooded households to have taken resistance and resilience measures, mirroring previous research (Harries, 2007) that highlighted the importance of flooding in promoting subsequent action. 27% of flooded households said that they had taken some measures to reduce the impact of flooding, while only 6% of non-flooded households had taken some steps.

2. Executive Summary

It is estimated that around 470,000 properties in England are currently located in areas subject to a significant (greater than 1.33% annual probability) risk of main river and/or coastal flooding (Environment Agency, 2006). This figure excludes properties which could be at a similar risk of flooding from minor rivers, surfacewater run-off and/or groundwater. The economic cost of flooding in these areas is considerable, currently reaching around £1.15 billion per annum (£747 million residential and £401 million commercial).

Although some of these properties could be provided with community-level flood protection by the Environment Agency over the coming years, in other areas the numbers of properties are so small or the cost of defences so large that the cost of additional protection is unlikely to be justified. Climate change is likely to increase the pressures on these properties and increases the need to consider a wider portfolio of flood management approaches, as advocated in the cross-government Making Space for Water strategy. This includes the greater use, by individual households and businesses, of flood resistance (i.e. measures to prevent entry of water into a building fabric) and flood resilience measures (i.e. measures to limit the impact of flood water within a building).

To investigate the economic benefits of using resistance and resilience measures, Entec UK and Greenstreet Berman were commissioned in June 2007 to undertake a research project entitled “FD2607 – Developing the evidence base for flood resistance and resilience”. This project was intended to provide analytical information for the wider Making Space for Water projects, RF1 and RF2 (encouraging and incentivising uptake of resistance products and resilience measures by households and businesses). It should be noted that the primary focus of the research is the application of flood resistance and resilience to existing properties rather than new development.

A key element of the project was the examination of the effectiveness of property based resilience and resistance measures in reducing flood risk. This involved developing a new economic model to quantify the costs and benefits of resilience and resistance at a property level. The model was developed for both residential and selected commercial properties and facilitated the quantification of property-scale benefits and costs for different packages of flood resistance and resilience measures. Descriptions of the packages for residential properties are outlined below in Table 1.

Table 1 Packages of Flood Resistance and Resilience Measures - Residential

Package	Measures
Temporary resistance	Manually installed door guards and air brick covers, sump/pump and remedial works to seal water entry points.
Permanent resistance	Permanent floodproof external doors, automatic air bricks and external wall render / facing, sump/ pump and remedial works to seal water entry points.
Resilience without resilient flooring	Resilient plaster (up-to 1m), lightweight internal doors, resilient windows and frames, resilient kitchen, raised electrics and appliances.
Resilience with resilient flooring	Concrete/sealed floors, resilient plaster (up-to 1m), lightweight internal doors, resilient windows and frames, resilient kitchen, raised electrics and appliances.

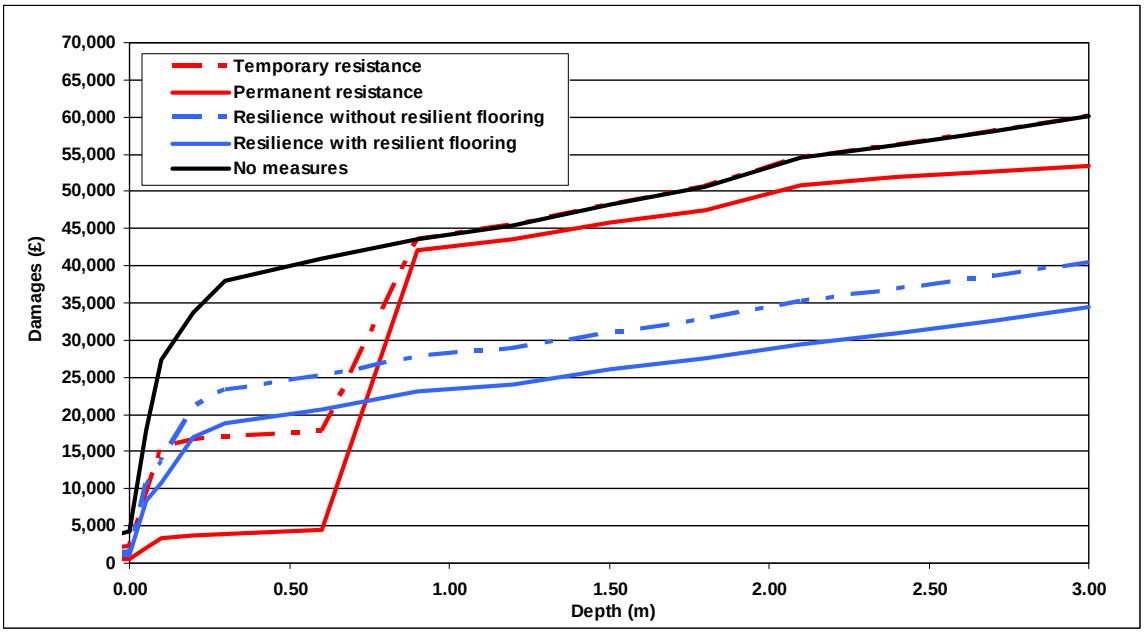
The study also investigated the incentives and disincentives that influence householders and small and medium enterprises (SMEs) in their decisions over whether to introduce resistance and resilience methods. These were investigated through face-to-face interviews with stakeholders (including insurers, loss adjusters, the National Flood Forum and representatives of CIRIA and RICS) and through a telephone survey of 1,131 householders and SMEs in areas of significant flood risk in England. This report describes the design, implementation and results of this research.

Developing a method to assess the benefits and costs of property-level flood resistance and resilience

One of the key outcomes of the study has been the development of a new spreadsheet model to enable the quantification of the benefits and costs for different packages of flood resistance and resilience measures.

Within the residential version of the model, six depth/damage profiles (namely Building fabric; Inventory (Home contents); Clean up; Alternative accommodation; Human health/stress; and Work absence losses) were developed for each of the packages of measures investigated. These profiles relate to the main elements of economic losses experienced by individual homeowners and businesses during a flood. These estimates were compared to the baseline estimated damages expected for a residential property with no additional flood resistance and resilience protection. Figure 1 illustrates the damage-reduction effectiveness of the various packages of measures for different depths of flood. (All of the values shown in this graph and the following tables are expressed using December 2007 prices and exclude VAT.)

Figure 1 Depth/damage profiles for different flood resistance and resilience packages



The economic model was also adapted to enable the creation of depth/damage profiles for two types of commercial properties, namely High Street Shop and Offices. The damage components assessed for these models were Building Structure and Fabric, Moveable Equipment, Fixture and Fittings, Stock, Services and Business Interruption costs (only used in Individual/Financial versions of the model).

Installation and maintenance costs for each the packages of flood resistance and resilience measures were also integrated into the model. These were estimated from information of the costs of 'Kitemark' approved products gathered in discussions with flood product manufacturers and from the recent Defra flood resilience pilot projects and previous research (ABI, 2003, Norwich Union, 2005).

The analysis conducted in the study suggests that, when deployed consistently and correctly, temporary resistance measures are economically worthwhile for properties with an annual chance of flooding of 2% or above (a 1 in 50 year return period) (Tables 2 and 3). The largest savings are in residential properties subjected to an annual risk of flooding of 4% or greater (1 in 25 years) or greater. For areas with the most frequent flooding, the benefits outweigh the upfront investment by a factor of between five and ten. Temporary resistance measures reduce the costs of damage from between 47% and 53%.

All of these relationships have been calculated on the assumption that temporary resistance measures are installed correctly and operated effectively during a flood event. Potential reasons why this may not occur are discussed later in this summary report.

Additional investment in permanent resistance increases the proportion of prevented damage to between 65% and 84%. However, because of their higher

cost, permanent measures are less cost-beneficial than temporary resistance measures.

The first of the resilience packages includes the use of water resilient plaster, wall materials and kitchens. The second resilience package adds the additional protection of resilient/concrete flooring. The analysis conducted has shown that, in most circumstances, the use of resilience measures will be less cost beneficial than resistance measures. However when a building is in need of repair or refurbishment following a flood, the extra cost of a resilient repair will be relatively low. This is reflected in the improved resilient repair benefit/cost values shown in Tables 2 and 3. However these values are still lower than for resistance measures and reflect the higher upfront installation costs of resilience measures.

Table 2 Economic benefit-cost ratios for different packages of flood resistance and resilience measures, including resilient repair – residential properties*

Annual chance of flooding	Return frequency (years)	Resistance Measures		Resilience Measures		Resilient Repair	
		Temporary	Permanent	Without resilient flooring	With resilient flooring	Without resilient flooring	With resilient flooring
20%	5	10.6	8.4	3.7	3.7	6.7	5.5
10%	10	5.8	4.3	2.1	2.0	3.9	3.0
4%	25	2.6	1.8	1.0	0.9	1.9	1.4
2%	50	1.3	0.9	0.6	0.5	1.0	0.7
1%	100	0.3	0.2	0.1	0.1	0.2	0.2

Table 3 Economic benefit-cost ratios for the use of different packages of mitigation measures, including resilient repairs – High Street Shops*

Annual chance of flooding	Return frequency (years)	Resistance Measures		Resilience Measures		Resilient Repair	
		Temporary	Permanent	Without resilient flooring	With resilient flooring	Without resilient flooring	With resilient flooring
20%	5	7.2	9.0	4.2	3.9	4.7	4.5
10%	10	3.9	4.7	2.2	2.1	2.5	2.4
4%	25	1.8	2.1	1.1	1.0	1.2	1.1
2%	50	0.7	0.9	0.5	0.4	0.5	0.5
1%	100	0.2	0.2	0.1	0.1	0.1	0.1

Notes:
The Benefit/Cost ratios presented in the above table have been calculated on the basis of a typical individual UK property (semi-detached) for which flood resistance and resilience have been installed correctly and work effectively during a flood event. Benefit/cost ratios were calculated by dividing the discounted benefit values by the discounted cost values for each of the flood resistance/ resilience measures. A benefit/cost ratio exceeding 1 represents a measure with overall benefit. Values calculated using a median value of the range of possible costs for the measures

However, the figures in these tables do not provide all the information that is needed for an individual to decide upon a specific resistance and/or resilience solution. Key considerations include an evaluation of the source(s) of possible flooding (e.g. riverine, sewer, groundwater or surface runoff) and the character of the people who use the buildings. These issues can only really be evaluated through a detailed flood risk assessment.

One important consideration for resistance measures is the fact that they need to be applied to all ground floor homes and businesses in any one block. If they are not, water can leak from unprotected properties into protected ones, thereby reducing the effectiveness of the protection. Resistance measures are therefore most suitable for detached properties or for terraced / semi-detached properties where owners are able to agree a common approach to flood resistance.

It is also important to remember that temporary resistance measures will need to be deployed immediately prior to a flood. It is also possible that these measures might not be deployable by some individuals (i.e. elderly or disabled) without the help of friends and neighbours.

Furthermore, the effective use of temporary flood resistance requires the presence and motivation of the property user, and they can be ineffective if people have forgotten how to use the measures, have mislaid them, are on holiday or, in flash-flood areas, if they are at work. In contrast, permanent resistance measures (e.g. waterproof doors and automatically sealing airbricks) are always available and do not need to be deployed. These measures are therefore more suitable for areas that are prone to flash-flooding or have a high proportion of elderly or disabled individuals, where the deployment of temporary resistance measures are not possible prior to the onset of the flood .

Another proviso to the general conclusions of the model is for properties that are vulnerable to groundwater flooding. Groundwater flooding occurs when the level of water in the ground rises to the level of properties and water enters cellars or ground floor rooms through the floor. This can be prevented either by a method known as ‘tanking’ (which is very expensive and was therefore not included in the model) or by the installation of concrete/resilient floors. Of the four packages of measures considered in the model only the most expensive – resilience with resilient flooring – provides some level of protection for this flood mechanism.

A further issue affecting the applicability of the model is the anticipated depth of flooding. As shown in Figure 1, resistance measures are normally more effective than resilience measures at limiting damage in shallower floods (though see the above exceptions). However, due to their ability to reduce restoration, clean-up and alternative accommodation costs, resilience measures should be more effective for floods of a sufficient depth to overwhelm resistance measures.

Finally, it must be remembered that the model takes no account of some of the less easily monetised benefits of flood risk mitigation, such as reduced anxiety and improved social cohesion. These considerations might make the use of the

packages worthwhile even when the benefit-cost analysis suggests that they are not. In addition, it is possible that the costs of many of the measures (notably the resistance measures) will reduce over time, leading to improvements in the benefit/cost ratios assessed in the study.

Understanding flood resistance and resilience from the individual's perspective

Assessing the economic argument from an individual's perspective

Householders' and businesses' perceptions of the benefits and costs of resistance and resilience measures are influenced by a range of factors not included in the economic model. These include the VAT on the cost of products, a tendency to heavily discount future benefits and the extent to which insurance terms are responsive to the particular risk circumstances of individual properties. The model was therefore adapted by incorporating VAT into the cost calculations, discounting future benefits by 5% (instead of the 3.5% rate used in the economic model), accounting for reduced business interruption in the benefits of resistance and resilience.

Sensitivity analysis suggested that, of these factors, insurance is the most influential. Where insurance terms accurately reflect the flood risk, measures are equally as cost-beneficial from the individual's point of view as they are from the societal point of view (i.e. beneficial for properties subjected to an annual risk of flooding of 4% or greater), but where they do not, resistance and resilience measures only become cost-beneficial to the individual householder or business at a 10% annual risk of flooding.

This evidence indicates that where insurance terms do not fully reflect the risk level, the benefit-cost ratio from the property owner's perspective is reduced. The situation also means that insurers are currently unable to offer significantly improved terms to motivate property owners to take flood resistant and resilient measures. Discussions with the ABI have indicated that where the level of flood risk is known, insurers are increasing premiums to more accurately reflect the risk, and hence help address this issue. However in the meantime, a partial knowledge of flood risk level combined with uncertainty over whether or not community based flood protection will be improved, means that property owners are not as motivated to protect their property as they might otherwise be.

Assessing individual perceptions and motivations - a telephone based survey

An individual's decision to invest in flood resistance and resilience will also be influenced by a range of other factors, including their perception of the risk and social trends. Furthermore, householders will not normally have access to perfect information about the cost and effectiveness of measures.

To investigate the factors that actually influence levels of uptake, a telephone survey of 1,131 households and businesses was conducted. Respondents for

this survey were drawn from lists of names, addresses and telephone numbers supplied by two data supply companies for postcodes that were identified by the Environment Agency NaFRA 2006 Postcode Flood Likelihood Category Database as having a greater than 80% concentration of properties at 'significant' risk of flooding (i.e. with a return period of 1:75 or higher).

Potential respondents were telephoned on week-days between 9am and 7pm and were interviewed for approximately fifteen minutes. People were only invited to participate in the full survey if they believed their property to be at risk of flooding. Approximately half of the respondents had experienced some kind of flooding in the past. Two thirds of the flooded householders had experience of flooding inside their home and 62% of flooded business respondents had experienced flooding within their main buildings.

The survey found that only around 25% of all businesses who responded stated they had developed an emergency plan for the eventuality of a flood and only 22% of non-flooded businesses had taken measures to protect their properties. The comparable figure for flooded business was 50%. The figures were even lower for households with only 6% of non flooded households and 27% of flooded householders having taken action to protect their properties.

The resistance/resilience measure of which households and businesses were most aware was the sandbag (Businesses – 33% flooded, 54% non-flooded; Households – 36% flooded, 60% non-flooded). This, in spite of the fact that most flood management experts consider sandbags a largely ineffective resistance technique. In addition, less than one in four were able to recall any resistance measures other than sandbags and only one in ten could think of an example of a resilience measure.

There was also clear evidence that householders and businesses generally believe in the principle of resilience and resistance. Sixty-four per cent of businesses and 61% of householders said that they believed such measures would save them money in the long term. In addition, 76% of householders and 82% of businesses said that they would make them feel safer and 78% of householders and 77% of businesses said that they would reduce disruption. A minority of respondents (about a third of householders and less than half of businesses) also agreed with the other benefits of resistance and resilience suggested in the survey, including the idea that it would increase the value of their property (see Tables 4 and 5).

Table 4 Householders' responses when asked if they agreed with various reasons FOR putting mitigation measures in place

	Agree %	Disagree %	Neither / don't know %
It would decrease the disruption if there was a flood	78	13	9
It would make me feel safer	76	17	7
It would save me money in the long term	61	23	16
My insurance premiums would go down or not go up so much	38	32	30
It would increase the value of my property	35	39	26

Table 5 Business' responses when asked if they agreed with various reasons FOR putting mitigation measures in place

	Agree %	Disagree %	Neither / don't know %
It would make me feel that the business was safer	82	11	7
It would save money in the long term	64	23	12
It would make customers feel that the business was less likely to be disrupted by a flood	63	26	11
The insurance premiums would go down or not go up so much	49	40	11
It would increase the value of the property	43	36	21
It would reduce the interruption to the business if there was a flood	77	18	5

In spite of the strong awareness of the potential long-term savings that such measures can bring (see above), around 45% of businesses and 57% of households said that they believed such measures would be too expensive. This could be a reflection of a high discount rate, which would reduce the value ascribed to savings in the future. However, it might also suggest that most people are uncertain about the real costs and benefits of the measures, as indicated by the fact that 17% of businesses and almost 50% of householders said that they do not know how much they would be willing to spend on mitigation measures.

In fact, when asked how much, hypothetically, they would be willing to spend on resistance and resilience measures, few householders and businesses came up with figures that were sufficiently large to yield the full benefits of flood resistance/resilience measures. It is therefore possible that some form of external financial assistance will be necessary to trigger an increase in the adoption of flood resistance and resilience by householders (and, to a lesser extent, businesses).

The survey indicated two additional widespread barriers to resistance and resilience. One of these was the belief that agencies responsible for managing flood risk had taken adequate mitigation actions and that no individual action

was therefore necessary. Forty-two per cent of householders and 24% of businesses said that they held this view. The second was the generally low level of awareness of the options for resistance and resilience. Only 22% of residential respondents were able to call to mind any resilience measure other than sandbags and only 10% were able to think of any example of a resilience measure – this, in spite of the fact that 47% of flooded households and 22% of non-flooded households said they had looked for information on how to protect their homes from flooding and 49% and 28%, respectively, said that they had received such information. Interestingly, 69% of non-flooded and 78% of flooded householders (and 73% and 78% of businesses, respectively) said that they would find out more about resistance and resilience if financial assistance were available to pay for it.

The survey also highlighted a number of additional reasons which could deter people from protecting their homes using flood resistance and resilience measures (see Table 6). These include:

- A quarter of householders say that they are deterred from taking mitigation measures by the belief that such measures would make their homes look unattractive.

- One in five said that they do not expect to remain in their current residence for very long and that this is a factor deterring them from taking measures. This suggests that adoption levels might tend to be lower in areas with more transient populations.

- Seventeen per cent say that they don't want to be reminded of the flood risk. However, given the stigma associated with this 'head-in-the-sand' attitude, this figure is not very reliable and is likely to be an underestimate.

- Around a quarter of all households (22%) said that they were concerned that the adoption of resistance or resilience measures might affect the value of their properties or make them hard to sell. This observation comes at a time when there is increasing evidence of a current slow down in the UK economy market. The continuation of less buoyant economic conditions could therefore be factor which might limit the future take-up of flood resistance and resilience by individuals.

- Half of the householders in the survey suggest that they are not confident in their ability to choose the right measure with which to protect their homes. This supports Harries' (2007) conclusion that doubt over how to act can be an important barrier to flood risk response.

Table 6 Householders' responses when asked if they agreed with various reasons FOR NOT putting mitigation measures in place

	Agree %	Disagree %	Neither / don't know %
I feel it would be too expensive	57	25	18
Collective measures have already been put in place	42	35	23
I don't think I would be able to choose the right way to protect my home	27	53	20
My home is covered by insurance so I don't need to worry	27	63	10
It would make my house look odd	27	57	16
I want my home to feel comfortable and look attractive	26	58	16
If I'm selling my home, I don't want people to see it's at risk of flooding	24	59	17
I don't think I'm going to live here much longer	20	66	14
I don't want to be reminded of the risk of flooding	17	78	5

It seems clear from the above discussion that a complex mix of barriers is deterring householders from taking property-level measures to reduce their exposure to flood risk. These barriers, furthermore, are certain to be interdependent. For example, people who believe that collective measures have already reduced the risk sufficiently are, it can be assumed, also likely to ascribe little value to household-level measures and, consequently, to think them expensive. The same could be argued of people who say they rely on insurance and those who expect to move home in the near future. This might explain why 30% of householders said that they were not willing to spend anything at all on flood risk mitigation.

Most of the barriers in this mix seem, however, to be less prevalent amongst businesses (Table 7) than they are amongst householders. This suggests that businesses would be more responsive to any campaign to increase take up of mitigation measures. Of particular interest, however, is the fact that 32% seem to believe that floods would not interrupt their business activity.

Table 7 Business' responses when asked if they agreed with various reasons FOR NOT putting mitigation measures in place

	Agree %	Disagree %	Neither / don't know %
I feel it would be too expensive	45	40	15
Even if the premises were flooded, the business would be able to continue uninterrupted	32	58	10
My business is not at risk because measures have been taken locally to stop this area from flooding	24	64	12
I don't think I would be able to choose the right way to protect my business	21	64	15
The business is covered by insurance so I don't need to worry	21	67	11
If I/we were to sell the premises, I/we wouldn't want people to see it's at risk of flooding	20	67	13
I don't expect the business to be here very much longer	13	80	7
I don't want to be reminded of the risk of flooding	11	85	4

The surveys also show that people with previous experience of flood events are more likely than those without such experience to have taken measures to protect their properties or to consider taking measures in the future. This finding supports the outcomes of the stakeholder interviews and research by McCarthy et al (2007) that experience of a flood influences the receptiveness of an audience to messages about flood risk and flood risk behaviour. This suggests that programmes to promote flood resistance and resilience will be most effective if targeted at homes/ businesses that have been flooded.

3. Policy suggestions

Eight key suggestions arising from the study have been identified for consideration by Government. These suggestions address a variety issues that currently limit the take up of flood resistance and resilience within residential and business properties.

a) Use of detailed flood depth / frequency data and ground survey prior to selection and installation of a flood resistance and/or resilience solution

Flood depth and frequency are key determinants of the overall effectiveness of any flood resistance and resilience solution. The importance of these factors has been reflected in the design of the economic model used in this study. Due to the importance of these factors, it is recommended that the suitability of future resistance/resilience installations are evaluated (where available) using detailed flood depth/frequency information.

Selection of suitable flood resistance / resilience measures will be best undertaken following a detailed flood risk assessment. These surveys should consider the full range of flood management alternatives, including improved drainage, demountable barriers and flood storage/SUDS as well as flood resistance and resilience. It is only through this process that the selection and investment in flood resistance and resilience measures can be fully justified. We recommend that the standard use of flood risk assessments forms an integral part of any expanded roll-out of the Government's flood resistance and resilience pilot scheme.

b) Encourage the greater use of flood resilient repair following major flood events

The economic modelling conducted in the study suggests that resilience measures are most cost effective when conducted as part of a programme of resilient repair following a flood. The experience of the Carlisle 2005 floods and National Summer 2007 floods has shown that major flooding can cause extensive damage to the internal building fabric (i.e. flooring, internal plaster, wall coverings and timberwork) of a property. This situation clearly provides an opportunity to enhance the flood resilience of the property. However, in many cases, flooded properties are re-instated using materials and techniques which are not flood resilient. This is largely due to the standard replacement process of insurance companies and the lack of any statutory requirements to use resilient methods to repair flooded properties.

We therefore recommend that the Government considers encouraging resilient repair through voluntary arrangements or through future updates of the UK building regulations. This should focus on cost-effective solutions that can be adopted in a majority of resilient repair situations. Examples include raised electrical sockets, use of PVC based skirting and use of lightweight flood resilient internals doors.

c) Identify the drivers that determine the extent to which insurance terms are based on levels of flood risk

The economic scenarios assessed in the study have shown that the provision of flexible insurance arrangements (including excess reductions for individuals who adopt flood resistance resilience measures) could help incentivise the take-up of flood resistance and resilience measures, especially for properties that are particularly vulnerable or have been flooded a number of times in recent years. As this is such an influential factor, we suggest that more work is undertaken to identify how the insurance market currently adjusts insurance terms in response to local circumstances of flood risk.

d) Improve awareness of flood risk and resistance and resilience measures

The survey of householders and businesses also revealed a number of factors that deter people from taking mitigation measures. These include feelings that they are expensive, the belief that collective measures have already reduced the risk, concerns about impacts on the appearance of the property and concern that such measures might adversely affect property values or make them harder to sell.

One way to address these barriers might be to ensure that future government-led policies include a clear communication strategy to enhance individual understanding of the benefits of using flood resistance and/or resilience. Any strategy would also need to be designed to encourage communication and backup planning with neighbours. This would help to improve the effective of temporary resistance solutions which might not be employed if person was not present at the property during a flood event. The effectiveness of this type of planning would clearly depend on individual circumstances but could be aided by government led initiatives.

We therefore recommend that any future initiatives to promote flood resistance and resilience are targeted at groups of homes or streets rather than at individual homeowners/business. This approach has a number of benefits, including economies of scale. This approach has been adopted within the recent Defra flood resistance and resilience pilots.

We also suggest that the Government's new Home Information Pack (HIP) includes better flood risk information and enables sellers to detail clearly the characteristics and benefits of any resistance and resilience measures which have been installed. This could, over time, help to encourage more home owners to invest in flood resistance and resilience measures, especially if it would act as a selling point for the property.

e) Consider the re-evaluation of the VAT rate for flood resistance and resilience products

The study's telephone survey suggests that cost perception is a major factor limiting the use of flood resistance and resilience measures by individual homeowners or small businesses. At present, the inclusion of the full VAT rate of 17.5% increases the cost of these measures and may, therefore, be adding

to the cost deterrent. Assuming an annual figure of 1000-3000 installations, each costing around £3000 (exc. VAT), and a reduction of the VAT to 5% would cost the Government between £0.4 and £1.1 million per annum. .This revenue reduction can be set against reduced state costs for recovery following major floods and the economy-wide reductions in damages that would result from an increased adoption of resistance and resilience measures.

f) Provide specific support for vulnerable people in flood risk areas

A number of previous research studies have shown that some social groups (i.e. long term sick, disabled, elderly, immigrants or people with low incomes) are particularly vulnerable to the consequences of major floods (McCarthy et al, 2007). It is also more likely that such individuals will be less able to invest in flood resistance and resilience measures. As a consequence, it is recommended that future government programmes to promote flood resistance and resilience (either through better information, provision of advice or grant based funding) provide additional support to these groups. This type of approach has been adopted in the government's Warm Front (http://www.warmfrontgrants.co.uk) scheme, which has improved access to insulation and energy efficient products for UK homeowners on state benefits.

g) Continue to improve the national assessment and reporting of properties located within areas at significant risk of flooding that are unlikely to receive community defences

For the benefits of resilience and resistance to be effectively promoted, it is important to be able to identify areas that have a sufficiently large residual flood risk to make them cost-beneficial. The Environment Agency's National Flood Risk Assessment (NaFRA) dataset currently provides three relative categories of flood risk, namely low, moderate and significant risk. Although the availability of this information provides a useful indication of relative flood risk, the current NaFRA risk categories are not sufficiently refined for this purpose. We therefore encourage the ongoing work within the NaFRA programme to enhance the methods used to calculate national flood risk probability, frequency and depth and thereby enable finer sub-divisions of the existing "significant" risk category.

h) Develop a process for monitoring the location and performance of flood resistance and resilience

There is currently no single mechanism for recording the location, age and performance under actual flood conditions of flood resistance and resilience products. It is therefore recommended that any future roll-out of the Government's flood resistance and resilience pilot scheme includes an internet-based system for recording the location, nature (i.e. type of measures installed), cost and performance of resistance and resilience measures. This could include recording depth of flooding; time before able to reoccupy property and time taken to undertake repairs. The creation of this system would require the involvement of a number of different agencies, including Defra and the Environment Agency, as well as of members of the public who had installed flood resistance and/or resilience within their homes or businesses. The recording of this information would help develop better estimates of the benefits and costs of individual measures and would hence aid the development of more sustainable flood management strategies within the UK.

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