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Phil. Trans. R. Soc. Lond. A 2002 **360**, 1511-1525
doi: 10.1098/rsta.2002.1013

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THE ROYAL SOCIETY

Vulnerability to flooding: health and social dimensions

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Published online 24 May 2002

This paper presents research results on the impacts that floods can have on the people affected, thus complementing the existing data on the monetary losses liable to occur in flood events. Both datasets should be used when deciding on investment in flood defence measures. We report on research on the vulnerability of flood-affected communities to adverse health effects, and the development of an index of community vulnerability based on extensive focus-group research and secondary-source census data.

Keywords: floods; impacts; health; community; vulnerability

1. Introduction

One of the key issues in managing flood risk with the threat of climate change is to determine the kind, and optimize the levels, of investment in flood defence measures. The prime function of this investment—and thereby managing flood risk and flood plains—is to protect people, property and precious environments from the damage and disruption that floods can bring. The prospect of an increasing incidence of flooding in a changing climatic regime does not alter this imperative.

Protecting property from flooding is catered for in investment decision making through its potential flood damage being counted within the fairly rigorous benefit–cost test that the UK Treasury insists is applied (Penning-Rowsell & Green 2000). Environments are protected—now sometimes irrespective of cost—by courtesy of DEFRA rules and European legislation creating SPAs, SSSIs, etc. But remaining relatively ill considered are the people affected by floods and the impacts that they suffer.

In this respect we need to understand better the 'social' effects of floods: those caused by the disruption of people and communities that do not or cannot carry a monetary price tag (Green *et al*. 1994). Floods can cause health impacts which are enduring, including the stress and trauma created months or years afterwards whenever floods again appear to threaten. These can be severe. Loss of treasured possessions in floods can be 'heartbreaking', and much more significant than financial losses, which are now commonly recovered through household insurance policies (Penning-Rowsell & Green 2000).

One contribution of 18 to a Discussion Meeting 'Flood risk in a changing climate'.

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What we cannot easily do is measure these 'intangible' effects in monetary terms, to build into the benefit–cost tests, and indeed we would not advocate that we try to do this. What we can do is to record these impacts in much more detail than has hitherto occurred, so that a proper balance can be struck between these effects and the more easily measurable money losses. We can also attempt to develop predictive models of these social effects, so that we can also plan to alleviate these in the future with our policies, plans and schemes—just as we plan to reduce flood damage—rather than just record them in our post-flood surveys.

This paper therefore contributes to the process of assessing the 'people dimension' that is now largely ignored in decisions about flood defence: we have methods to gauge the economic gains and losses from such investment decisions but not the degraded life quality that follows floods for many of their victims. We also report on research that seeks to predict the 'social impacts' of floods so that we can alleviate them more purposefully. Both will be increasingly important if climate change does indeed bring greater flood threat.

2. Health and community flood impacts: research in northeast England following the June 2000 floods

(*a*) *Research focus and methods*

Between 3 and 5 June 2000, parts of northeast England experienced flooding which was unusually severe and extensive for the time of year (Environment Agency 2000). On the evening of 3 June, high-intensity localized rain fell in a number of areas, flooding over 1000 properties. Three of the communities affected were Todmorden in Calderdale, Lancashire, and West Auckland and South Church, in County Durham. In Todmorden the Upper Calder River flooded approximately 500 properties, while in West Auckland and South Church some 430 were flooded by the River Gaunless in an event having a return period of *ca.* 1:100 years (Environment Agency 2000).

In Todmorden a full flood-warning service was in place, while in West Auckland and South Church no such service then existed. However, the 'flashy' nature of the catchments, in addition to other complicating factors such as the collapse in Todmorden of two flood walls, meant that warnings were not issued in any of the locations prior to flood waters entering properties. Flooding in all three locations occurred at night, thus making response by emergency services and local residents more problematic. The flooding, therefore, had considerable impact upon individuals, households and communities in the three locations.

Our model of flood impacts (figure 1) is based on more than a decade of research on the social dimensions of floods (Penning-Rowsell & Green 2000). It sees these impacts as the net effect of the threat, the mediating influences that moderate that threat for the affected population, and the support capacity in households, communities and indeed the nation that helps to promote resilience in that population and the capacity to recover from the threat, the event and its effects. Our methods involved a qualitative approach using focus groups to match previous research in the Thames region (Tapsell *et al.* 1999). A focus group is a carefully selected group of people who meet to discuss particular questions raised by a moderator. Focus-group discussions enable these people to share their views and feelings about an issue. In the past such qualitative research was not valued because it was not seen as facilitating generalization and theory building. However, these methods are now seen to have

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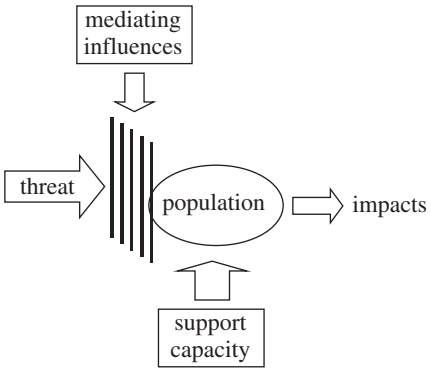

Figure 1. The process model of vulnerability to flooding: threats, impacts and mediating influences (courtesy of Colin Green).

a key role to play in explaining and interpreting people's lives, actions, perceptions, fears and feelings, particularly when researching sensitive issues such as flooding. The reporting of qualitative data is suggested by Miles & Huberman (1994, p. 299) as possibly being 'one of the most fertile fields going [as] there are no fixed formats'.

A total of six focus-group meetings were carried out in September and October 2000, three to four months after the flooding. Four meetings were held in Todmorden and one each in West Auckland and South Church. All the focus-group sessions were tape recorded with the participants' permission and later fully transcribed. An observer was present, along with the moderator, to take notes and observe responses. Only a summary of the full results can be presented here. Table 1 gives information on the key elements of the range of results obtained, and this paper concentrates hereafter on health effects. For full details see Tapsell & Tunstall (2001).

(*b*) *Physical health effects*†

Previous research has indicated that natural disasters such as flooding can impact upon people's health in a number of ways (Parker *et al*. 1983; Green *et al*. 1985*a*; Tapsell *et al*. 1999; Ohl & Tapsell 2000), good health being defined as complete physical, mental and social well-being (World Health Organization 1948). The physical health effects reported by focus-group participants after the June 2000 flooding are shown in table 2. These largely correspond to effects reported by respondents in the earlier Thames region study (Tapsell *et al*. 1999), and many are associated with the trauma of the flooding and living subsequently for long periods in damp and dirty conditions.

Many people reported suffering from diarrhoea and upset stomachs following the floods, while others spoke of other types of infection. The close proximity of people living in cramped conditions in their homes following the flood also meant that some of these adverse health effects were passed from person to person within the household. Several people spoke of feeling generally unwell, although they could not give any specific symptoms. There was also the suggestion that the full health impacts of the flood have yet to reveal themselves. This was also mentioned by people

† Detailed quotations from the focus-group members to support the summaries in this section are available in Tapsell & Tunstall (2001).

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Table 1. *Summary results from the focus-group meeting surveys in the northeast of England following the spring 2000 floods (focus-group meetings held in October/November 2000)*

Key summary points: attitudes, stresses and behaviour before the flooding
Before the flooding there was little awareness or expectation of the risk of serious flooding in Todmorden and West Auckland and no awareness in South Church.
Although some people had experienced past flooding in their properties in Todmorden and West Auckland, in only a few of these cases was this serious.
The majority of people were not prepared to cope with the flooding.
People generally felt that the risk of flooding should have been made clearer by the Environment Agency.
Key summary points: attitudes, stresses and behaviour during the flooding
During the flood people had been shocked at what was happening, and at the power, speed and depth of the flood waters.
The risk to life from the flooding was highlighted by many people.
Most people had received informal warnings which had allowed some to save a few possessions; apart from this there was little people could do.
Some help was received from emergency services, friends and neighbours, but many people had to help themselves.
Various authorities, including the Environment Agency, were criticized for their lack of support.
Key summary points: attitudes, stresses and behaviour after the flooding
Damage to property and losses from the flood were extensive. The most important losses were irreplaceable personal items and memorabilia.
For those who were evacuated from their homes the experience was stressful and several people had still not returned to their properties. Little rental accommodation was available locally.
Those who did not evacuate faced months of living in damp and dusty conditions and the prospect of being surrounded by empty properties. Disruption to daily life was therefore great among both groups.
Taking time off work to recover from the flood had caused problems for people, not least through the loss of income, but for a few people going to work offered some respite from the flood recovery process.
Local authorities were generally criticized over what was perceived as insufficient support during the recovery process.
The main forms of support required were suggested as being ‘manpower’, advice and counselling. Voluntary support was generally well received.
Key problems were experienced with loss adjusters and insurance companies, particularly regarding differing levels of service offered. Those without insurance faced additional problems.
Builders and contractors repairing properties were also heavily criticized for their poor standards of service, unreliability and unpleasant attitudes.
Strong feelings were expressed of having to ‘fight’ for any advice and assistance in the recovery process. The effects of this had significant implications for people’s health and well-being.

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Table 1. (*Cont.*)

Key summary points: health effects
Many people had suffered from physical health problems since the flooding, often associated with coming into contact with contaminated flood waters, living in damp properties, etc.
Concern was expressed over the health risks from contaminated flood waters and the associated lack of, or conflicting, advice given by various authorities on these health issues.
The majority of participants admitted to feeling extremely 'stressed' by the flooding and recovery process and some were displaying signs of common mental disorders associated with experiencing a traumatic event.
Anxiety during rainfall was common among focus-group participants since the flooding, and many had adjusted their behaviour (e.g. by regularly monitoring the river levels) due to the fear of possible future flooding.
The most devastating aspects of the flooding were largely said to be financial, no time for 'living', the loss of 'everything people had worked hard for', and feelings of helplessness.
Key summary points: security and community cohesion
Issues related to future security concerned the fear of future flooding and the loss of security people now feel in their homes—no longer a safe refuge.
Homes no longer have the same meaning for people as they did before the flooding.
Many people felt the need to know how to protect their homes from any future flooding.
The media were perceived as being intrusive and insensitive following the flooding.
Significant adverse effects were demonstrated by the disruption to, and deterioration of, community life, particularly in West Auckland and South Church.
Key summary points: attitudes to the authorities
The general feeling was that the various authorities had responded poorly following the flooding, particularly the local Council.
People had little confidence in the authorities to predict future flooding, provide timely warnings or provide support.
The Environment Agency was the only agency perceived to be taking some action, although these actions were frequently seen as being too little and too late.
The perception of focus-group participants was that the authorities, including the Environment Agency, had no real commitment to flood prevention.
Various factors were seen to have caused or exacerbated the flooding—some of these were accurate and some were not.

following the 1998 flooding, when it was only after people's homes had been put back in order that the full extent of what had happened was appreciated (Tapsell 2000). This further indicates that the effects of flooding on people's health and general well-being can continue for many months after the actual flood event.

The research reported here shows that people's health before flooding can be a factor affecting the extent of health impacts experienced by flood victims. A number of preexisting health problems were highlighted in the focus groups by flooded individuals, either for themselves or for close members of their families. For exam-

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Table 1. (*Cont.*)

Key summary points: vulnerable groups

Certain groups within the communities affected by the flooding were seen to have suffered more pronounced effects than others. These groups were thought to need particular support and consideration.

The flood was perceived to have had significant impacts on children, women, the elderly and disabled, both physically and psychologically.

Children were thought to have been ignored by the authorities in the aftermath of the flooding. Many were said to have been very upset at the loss of treasured possessions and the disruption of their daily routines. This had led to behavioural problems and increased anxiety levels during rainfall.

Parents wanted to be given advice on how to deal with children after flooding and the sort of impacts they might face, and the availability of psychological or emotional support for children in the aftermath of flooding. Creches and child-care facilities where children could be left while parents were coping with the recovery period were also suggested.

The flooding was seen to have had differential impacts upon men and women. Women were seen to be particularly affected by the flooding, both physically and psychologically. Single women were thought to have been taken advantage of by insurance companies and builders.

Support for the elderly and disabled following the flooding was seen to be generally inadequate.

Table 2. *Physical health effects reported by focus-group participants*

Todmorden	West Auckland	South Church
asthma	coughs	blood disorder
chest infections	diarrhoea/ upset stomachs	chest infections
coughs/colds/flu	kidney infection	coughs
diarrhoea/vomiting/ upset stomachs	laryngitis	diarrhoea/ upset stomachs
headaches	pleurisy	high blood pressure
skin irritations		kidney infections
spots		panic attacks
swollen glands		pleurisy
throat and ear infections		viral infections

ple, one woman in Todmorden was in remission from cancer, one male suffered from multiple sclerosis and another elderly man had osteo and rheumatoid arthritis. One respondent's wife in West Auckland had suffered a heart attack six weeks before the floods; another woman who had been badly affected by previous flooding reported suffering prolonged stress and ill-health since the event. Many of these people had either seen their health conditions exacerbated after the June 2000 flooding, or had been concerned that they would be.

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Most of the focus-group participants had visited their local doctor following the floods. Several spoke of difficulty in getting appointments due to the large numbers of people in the same situation. Having to wait for a week or two did not appear to be uncommon. The costs of repeat prescriptions had been high for one woman, who said that she could ill-afford to pay for them. Many doctors had attributed their patients' health problems to the stress of the flooding and the living conditions with which people had to cope. Several respondents spoke of doctors not being able to state whether the flood had been the cause of their health problems. The idea of being labelled as a 'flood victim' by her doctor had upset one woman who said that it made her feel 'like a leper', while one South Church woman had not been to her doctor for fear of losing her job owing to gaining a reputation for ill-health.

The flood-action group in South Church was concerned that the health effects of the flooding would be ignored by the authorities because, according to the council, there had been no cases of 'disease' reported by local GPs to the Health Authority. The Chief Executive also stated that, although the Council were frequently in contact with the communicable-diseases department and were getting reassurances that no diseases had been reported, it is only serious diseases that are reported. Therefore, people can be quite ill following floods but may not be reported as being so by their doctors.

People's ongoing concerns about their physical health were largely associated with the perceived health risks from streets not being cleaned following the flooding (particularly where children were playing in these environments). Health risks from contaminated drinking water were also mentioned during the focus-group meetings. Several people had sought advice on this from various sources and had largely been reassured that there were no serious risks. However, associated with these concerns was the fear of rats, and the danger to health from diseases that they may carry. Several people were particularly worried about diseases such as hepatitis, typhoid and Weil's disease.

A further concern related to possible bacteria left in the building materials of properties following the flooding. Some people were disturbed that they had not been offered vaccinations against hepatitis, as the police had apparently been. There was more concern when it was suggested by several people that the reason they had not been offered these vaccinations was because mass vaccination was too costly. A number of people stated that they would have been willing to cover any such costs themselves.

One issue which was of concern to most of the people taking part in the focus-group meetings was the lateness of advice on dealing with contaminated possessions. Flyers were sent out by local authorities a day or two after the floods, advising people to wash their hands if they were handling contaminated goods. Most people stated that these notices arrived too late as they had immediately begun to clean their homes the moment the flood waters had receded. Conflicting information and advice on health issues given by different authorities was another area causing anger and concern.

A further concern to participants in West Auckland was whether the flooding had contributed to increased mortality rates in the affected areas, albeit of those who were already elderly or sick. There is evidence that death can be hastened by the experience of flooding, rather than somehow being caused by it. Following the 1968 flooding in Bristol, Bennet (1970) reported that mortality rates for the 12 months following the flood increased significantly in the homes of people who were flooded.

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(*c*) *The mental health effects of flooding*

The general conclusion from all six focus-group meetings was that everyone had suffered from, or was continuing to suffer from, psychological health impacts from the stress of the flooding. Stress is seen as arising from the difference between the perceived demand the event places upon the individual and the resources the individual can draw upon to adapt to that demand (Green 1988). The severity of the impact represents the degree to which coping and support capacity are insufficient to cope with the challenge and the costs of responding (figure 1). Moreover, the stress associated with a particular disaster is not limited to the time that it occurs, and both short-term and long-term stress reactions can be evident in disaster victims (Holen 1991; Boscarino 1997). Evidence from the Thames region study (Tapsell 2000) showed that the psychological effects of flooding can continue for months or even years after the event, and are often more pronounced than the physical health effects.

It is expected that people who experience a traumatic event will have a severe reaction to it, particularly in the first few days after the event (e.g. Ticehurst *et al*. 1996). For people who display symptoms beyond this period there are three possible diagnoses: adjustment disorder, acute-stress disorder, and post-traumatic-stress disorder. The three can be differentiated by the type of stressor, and the range and duration of symptoms (Rick *et al*. 1998). Many people in the focus groups were displaying symptoms of impaired mental health such as those related to adjustment disorder (Rick *et al*. 1998). These symptoms included avoidance of talking or thinking about the flooding, flashbacks, sleep disorders and depression.

Only a few people in the northeast England focus groups felt that they were now 'over' the flood, and these tended to be men rather than women. The chairperson of the flood-action group stated that she 'would not know where to begin' to evaluate the psychological impacts of the flooding on the community. It was suggested by participants in South Church, as well as the chairperson of the flood-action group, that substance abuse, such as reliance on alcohol and prescription drugs, had probably risen since the flooding, or would increase in the future.

The nature of the trauma (e.g. flood event) may impinge upon the severity of symptoms. Research suggests a complex relationship between the experience of a traumatic event and subsequent mental disorders. Evidence from the focus groups suggests that the greater the damage, losses and inconvenience from a flood event, the greater the stresses suffered by flood victims are likely to be. Several people in the groups stated that they could not cope with another flood and the associated impacts it would have on them and their households. One couple felt that keeping occupied with the recovery process had helped them cope with the event.

There was often no escape from the stresses of recovery. One female participant in Todmorden spoke of the relief she had felt when able to take a brief holiday. On the other hand, there were some positive outcomes from the flooding for a few participants in the focus groups. One older woman felt that the experience had helped her assess some long-term childhood anxieties, and two other women said that they had become good friends since the flooding and that many people now knew neighbours with whom they had not previously been acquainted. Several people spoke of being able to laugh at their experiences and that a sense of humour helped them to cope with what had happened.

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Following a flood, subsequent rainfall can act as a trigger for repeated stress and trauma among those who were flooded, being a factor directly related to the initial flood event. Most focus-group participants in all the three locations we studied expressed concern and anxiety during heavy rainfall since the flooding, matching the findings from our previous studies (e.g. Tapsell *et al*. 1999). Increased awareness of the hazard meant that some people had begun to differentiate between the various intensities of rainfall and had started to refer to these different types. This reflects the situation in the Thames region study where people had began to refer to 'Easter rain' to differentiate it from 'normal' rainfall.

(*d*) *Changes in behaviour since the flooding*

Many people had changed aspects of their behaviour since the flooding. This ranged from moving possessions to higher parts of the house to refurbishing the property differently in case of future flooding. These same behavioural patterns were also noted in the Thames region study.

Disasters and their aftermath can have significant impacts upon people's relationships, both within the household and with those outside. A few people in the focus groups spoke of positive changes in relationships with their partners as a consequence of the flooding, but some mentioned relationship problems in their households and in the community due to the stress of the flooding and the recovery process.

When people were asked what had been the most devastating aspect of the flooding at a personal level, responses varied from citing financial impacts upon households, to 'lost' time, disruption of family life, losing everything that people had worked for, and the loss of sentimental possessions. Some people referred to the feeling of powerlessness and helplessness and not being able to do anything to stop the flood and save their homes. The chairperson of the flood-action group found it difficult to say which of the many serious impacts of the flooding on people had been the worst: for herself and others in the action group, dealing with the flood had literally 'taken over their lives'.

3. A proposed Social Flood Vulnerability Index (SFVI)

Given an increasing appreciation of the full impacts of floods, from research such as reported above, we have sought to develop an index which measures the impact that floods could have upon the communities potentially affected. We anticipate that this index would be used in addition to knowledge of the potential flood damage impacts and losses that are more readily understood and modelled within benefit–cost analyses within investment appraisals. We outline here, therefore, the definition and source of the variables used in the calculation of the Flood Hazard Research Centre (FHRC) SFVI, which can be used to predict those areas and populations that are likely to be most severely affected in terms of health and other 'intangible' flood impacts.

Our choice of data was constrained by the need, first, to use secondary source data that are available for the whole of England and Wales, rather than rely on expensive and time-consuming interview or focus-group approaches. We also needed, secondly, to use data that are available for small geographical areas, because flood plains are often narrow and short. We used 1991 census data from the Manchester Information

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and Associated Services (MIMAS), because these data fit the above criteria, being available for England and Wales at the level of the enumeration district (ED).

(*a*) *The SFVI and its constituents*

The SFVI is a composite additive index based on three social characteristics and four financial-deprivation indicators. The rationale for the selection of these variables is given in table 3, and figure 2 maps these and other variables against the six case studies that we have undertaken over several years to quantify the 'intangible' impacts of flood events. The linkages shown in figure 2 are based on our best judgment, supported by results from the hundreds of interviews in those studies, of the relative effect of the different variables in determining household vulnerability in the types of floods experienced in those localities. It shows that the age and financial status of the affected populations are the most commonly important variables, followed by the prior health status of the population. We have chosen to use the incidence of lone parents as a measure of family structure, because our research points to this causing extremes of vulnerability, although the presence or absence of young children (to which the incidence of lone parents is very closely correlated) had, perhaps, an equal case for inclusion.

To identify the financially deprived, the Townsend Index (Townsend *et al*. 1988) was used because, unlike other deprivation indices, it focuses on deprivation outcomes (such as unemployment), rather than targeting predefined social groups. This enabled us to identify our own social classification. This is important because financial deprivation is only one of several factors that contribute towards vulnerability to flood impacts and it is our intention to target only those social groups which previous research has shown to be particularly badly affected.

The Townsend indicators are as follows.

(1) **Unemployment:** unemployed residents aged 16 and over (S090019+S090043) as a percentage of all economically active residents aged over 16 (S090013 + S090037).†

(2) **Overcrowding:** households with more than one person per room (S230003 + S230004) as a percentage of all households (S230001).

(3) **Non-car ownership:** households with no car (S210003) as a percentage of all households (S210002).

(4) **Non-home ownership:** households not owning their own home ((S200001 + S200009) − (S200002 + S200003)) as a percentage of all households (S200001 + S200009).

In order to prevent any undue bias in the SFVI towards financial deprivation, the four Townsend indicators were summed and multiplied by 0.25 before being added to the other variables. Those other variables and the social groups that they highlight are as follows.

(1) **The long-term sick:** residents suffering from limiting long-term illness (S120001) as a percentage of all residents (S010064).

† These codes refer to the tables provided by MIMAS. Hence S090019 refers to census Small Area Statistics, table 09, variable 0019.

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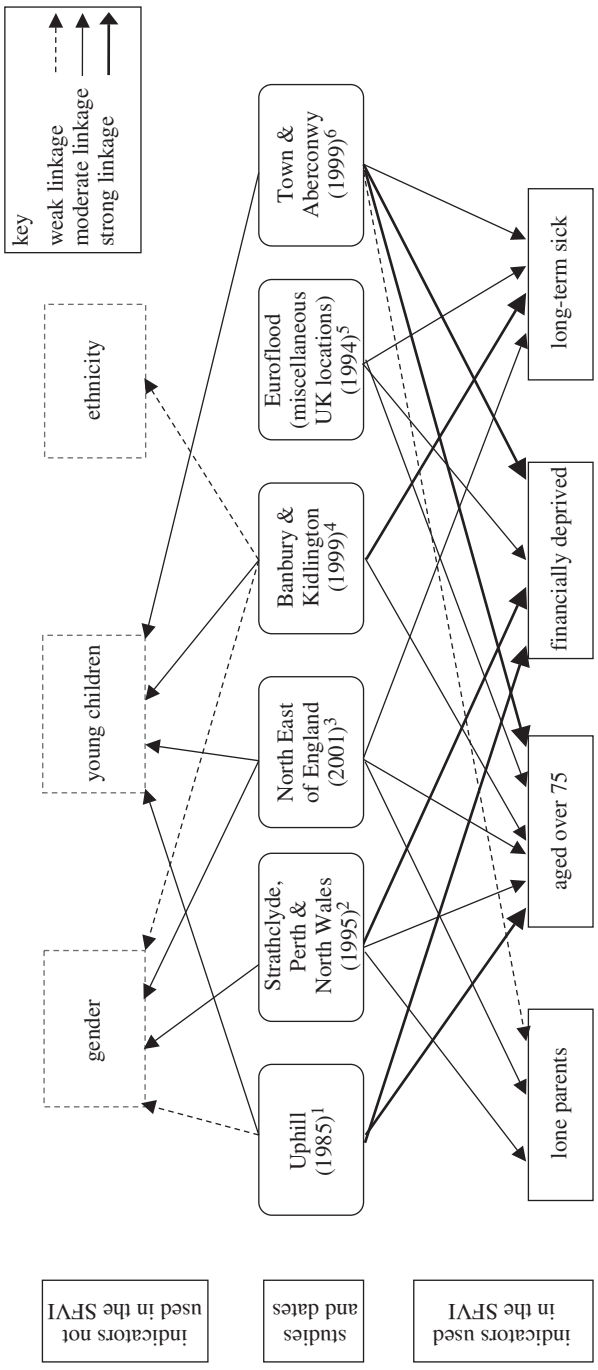

Figure 2. The relationship between results from a range of case studies and the choice of variables for the SFVI (based on qualitative social science methods in focus-group research, without control groups). References labelled in the figure are as follows: 1, Green *et al*. (1985*b*); 2, Fordham & Ketteridge (1995) and Hill & O'Brien (1999); 3, Tapsell & Tunstall (2001); 4, Tapsell *et al*. (1999); 5, Ketteridge & Green (1994); 6, Hill & O'Brien (1999).

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Table 3. *Our rationales for the selection of variables for the SFVI (based on qualitative focus-group research)*

variables	rationale
elderly (aged 75+)	The age of 75 was chosen because epidemiological research has shown that after this age there is a sharp increase in the incidence and severity of arthritis (and other conditions) and this illness is sensitive to the damp, cold environmental conditions that would follow a flood event.
lone parents	Previous FHRC research has shown that lone parents (of either sex) are badly affected by floods because they tend to have less income and must cope singlehandedly with both children and the impact of the flood, with all the stress and trauma that this can bring (Green *et al*. 1987).
preexisting health problems	Research by FHRC has shown that post-flood morbidity (and mortality) is significantly higher when the flood victims suffer from preexisting health problems (Green *et al*. 1994).
financial deprivation	The financially deprived are less likely to have home-contents insurance and would therefore have more difficulty in replacing households items damaged by a flood event (and it would take longer).

Table 4. *Transformation methods used in the compilation of the SFVI*

indicator	transformation method
lone parents	log natural $(x + 1)$
aged 75+	log natural $(x + 1)$
long-term sick	square root
non-homeowners	square root
unemployed	log natural $(x + 1)$
non-car owners	square root
overcrowding	log natural $(x + 1)$

(2) **Single parents:** lone parents (S400001) as a proportion of all residents (S010064).

(3) **The elderly:** residents aged 75 and over (S020127 + S020134 + S020141 + S020148) as a percentage of all residents (S010064).

(*b*) *Data processing*

The crude percentages were transformed by the method that produced the minimum skewness and kurtosis within their distributions. The selected transformation methods are shown in table 4. Following transformation, the data were standardized as Z-scores and then summed (as stated above, the Townsend indicators were summed separately and then multiplied by 0.25 prior to their inclusion in the index).

The completed SFVI has a minimum value of −10.4, a maximum value of 9.07, a mean of 0.06 and a standard deviation of 2.56. Given the relatively exploratory nature

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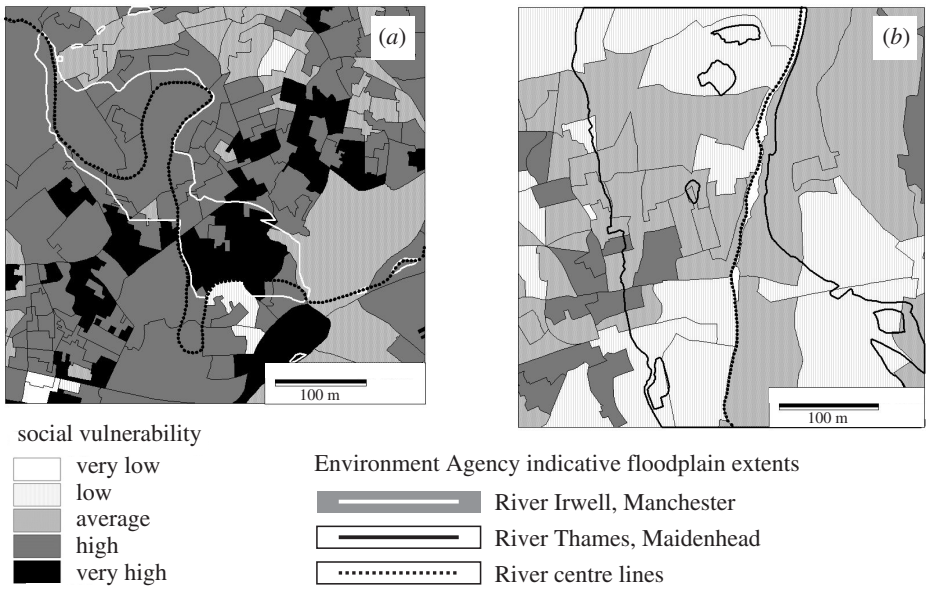

Figure 3. The results for the SFVI for (*a*) Salford, Manchester, and (*b*) Maidenhead.

of this work, the SFVI was then categorized into a limited number of bands (five), where category (1) represents low vulnerability, category (3) average vulnerability and category (5) high vulnerability, etc. Also, out of 113 465 EDs in England and Wales there are 4982 missing values. This is due to either null values in the indicators or, in some cases, data for the ED are 'suppressed'. Data for a ward or ED are suppressed when its population is considered to be so low that individual households or persons could be identified from the census data that are released.

Figure 3 gives the results for two areas of the UK where flood-alleviation schemes have been implemented in the recent past, showing for Maidenhead that the flood plains are populated by relatively affluent communities with slightly lower average SFVI values than in the surrounding areas. The Manchester communities, by this measure, are much more vulnerable to flooding than their Maidenhead equivalents, with a large vulnerable community in the southwest of the flood-plain area (in the centre of figure 3*a*). Further research is needed to gauge how accurately actual vulnerability to flooding is predicted by these SFVI scores. That research should perhaps both attempt to 'hindcast' the existing focus-group research results from the index values and assess the actual vulnerability of populations affected by future floods in comparison with the predicted scores.

4. Conclusions

The conclusions from this research are simply that the impacts of flooding are more extensive and complex than have hitherto been appreciated, and that assessments of the effect of flood-defence measures on reducing these impacts are flawed if only monetary losses are used within the necessary project-appraisal methods. If flooding is to become more frequent or more severe under regimes of altered climatic conditions, governments will need to allocate even more resources to this area of public

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expenditure. There is no failure to appreciate this now in government circles, following major flooding in 1998 and 2000; the test will come when these floods are forgotten by those who were not directly affected, and decision-makers move on to other investment priorities within the public domain.

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