

## **Flooding, Social Resilience, and Public Health issues in the UK**

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### **Key words**

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### **Abstract**

This paper examines human health risks in the UK from flooding. It first outlines factors affecting general social resilience to disaster risks and then considers four main aspects from the point of view of public health:

- direct impacts on physical and mental health,
- impacts arising from damage to critical infrastructure such as water and electricity supplies.
- indirect impacts arising from animals including zoonoses and waterborne pathogens.
- effects of companion animals and livestock on evacuation behaviour.

Evacuation is an increasingly important aspect of flooding risks, and the public health impacts of evacuation have received little research in the UK. For example, research in the USA on the impact of pet ownership on evacuation behaviour has received almost no attention in the UK. It seems clear that pet ownership can dramatically reduce the number of people prepared to evacuate from disaster zones and the loss of a companion animal can significantly contribute to the emotional impacts of a disaster.

## **Introduction**

Predicted climate change health impacts include disasters from heat waves, diseases, storms, and floods<sup>1</sup>. This paper focuses on flooding risks. The 2007 floods in England forced 14,500 families into temporary accommodation, and raised again the spectre of foot and mouth disease in a farming community still recovering from the 2001 outbreak.

Disasters are a test of social resilience. The first part of this paper looks at risk in terms of social resilience issues.

The paper then considers public health risks from flooding and the impact on health and evacuation behaviour from the ownership of pets and livestock in the wider context of the UK as a whole. Companion animals and livestock are a special type of property. If a pet is lost or injured, this can have a devastating effect on the health and welfare of the owner's household. Livestock farmers may be less emotionally involved with their stock but farmers are still a high risk group for suicides<sup>2</sup>.

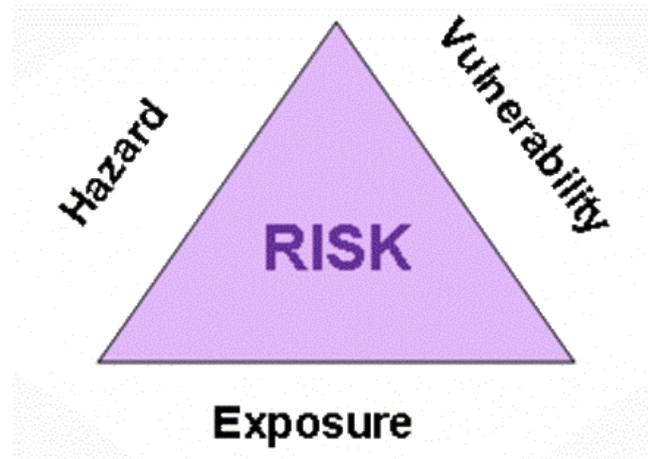
## **Flood risks and Social resilience**

Disaster impacts can be particularly severe on some of the most vulnerable people in our society, and these are the people who can find it harder to recover from them when they happen. Disasters tend to widen existing inequalities unless social resilience can be addressed. If not the differential social impacts may lead directly to increased costs for the economy in terms of healthcare and social care. It is more difficult to measure social and emotional costs suffered when flooding disrupts business, destroys farmland, and disturbs family life. Even if people are fully insured, the intangible impacts can be significant<sup>3</sup>. Evacuation of residents undoubtedly fragments and disrupts communities and the stressful effects of anxiety and insecurity may remain long after the water has subsided. While more research needs to be done, there is evidence of higher levels of mental illness after a flood<sup>4,5</sup>.

## **Risk Reduction**

The "Crichton Risk Triangle"<sup>6</sup>, was designed for use by the insurance industry for catastrophe modelling (see Figure 1).

**Figure 1. The "Crichton Risk Triangle" (© Crichton, 1999)**



In this definition, risk is a function of hazard, exposure and vulnerability.

### **Hazard**

In the case of flooding, "Hazard" represents the frequency and severity of rainfall events or storms. Climate change predictions indicate an increasing hazard over which society has little immediate control other than to clean watercourses, provide adequate drainage<sup>7</sup>, and adopt natural flood management practices<sup>8</sup>.

### **Exposure**

This represents the density and value of property located in flood hazard areas. A hundred years ago, when most people walked or cycled to work, homes in England were built to a density of 250 dwellings per hectare. This gradually fell over the 20<sup>th</sup> century with the greater use of cars and buses until by 2000, the average density was only 25 dwellings per hectare, the minimum density for a viable bus service. This, combined with smaller, often single person, households has meant a huge demand for land for development. As fuel prices rise, density is now creeping up again and new build has reached an average of around 40 dwellings per hectare in England<sup>9</sup>. In the Thames Gateway floodplain, a density of 200 dwellings per hectare is planned.

Building in flood hazard areas increases the risks to life. The centre of Paris had a catastrophic flood<sup>10</sup> in 1910, but despite that, 154km of underground railway has been constructed in the city and 600,000 underground car park spaces have been built near the river with basement depths up to 10 levels. After 39 people were killed in floods in Turkey in November 2006, Tansel Unal, the Head of the Chamber of Construction Engineers in Diyarbakir, blamed the high toll on faulty building practices in the region, notably on settlements built in river basins.

*"Nowhere (else) in the world, is construction authorized in river basins," he said<sup>11</sup>.  
"Negligence and badly planned urbanization are the real cause of high death tolls, be they due to floods or earthquakes."*

This is not quite correct: there is somewhere else in the world which still authorises construction in river basins and other flood risk areas: see Table 1.

**Table 1: Percentage of all new dwellings built in flood risk areas in England, by region, 1996 to 2005**

Source: Land Use Change Statistics, Dept of Communities and Local Government.

Region	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005*
North East	6	5	2	3	1	2	2	3	2	2
North West	5	5	7	5	6	9	6	8	5	4
Yorkshire and the Humber	11	12	7	10	13	12	11	15	10	13
East Midlands	10	12	6	7	9	11	13	13	11	9
West Mids.	7	4	6	6	2	4	5	4	5	3
East of England	6	7	8	7	7	6	7	8	7	13
London	27	25	26	24	23	20	21	28	26	18
South East	6	8	9	10	9	10	8	10	7	7
South West	5	6	6	8	7	8	10	7	8	7
England	9	9	9	9	9	9	10	11	10	9

\* Provisional figures

### Vulnerability

Countries such as Japan, Germany, France, Holland and Scotland concentrate nowadays on managing hazard and exposure<sup>12</sup>. Increasingly they work together, for example, Germany is working with France on the Moselle catchment<sup>13</sup> and with Scotland on new flood management techniques developed under the SAFER project<sup>14</sup>.

There is of course an important role for civil engineers in designing structural flood defences such as walls, culverts or reservoirs to reduce vulnerability especially for critical infrastructure<sup>15</sup>. However there are dangers to a one dimensional approach.

1. Some research suggests that structural defences can actually increase the risk<sup>16,17,18,19</sup>. For example sudden failure can lead to bigger losses. Flood defences can give a false sense of security as was found in the Grafton incident<sup>20</sup> in Australia in 2001, where residents refused to leave because they were convinced the defences would protect them (in the event they did, but only just.) Often the perception of risk can differ dramatically from the real risk<sup>21</sup>.
2. Structural defences transfer the risk onto future generations, along with the maintenance and repair costs<sup>22</sup>.

3. New defence programmes cannot keep pace with current floodplain developments in countries such as England and take resources away from other capital projects.

Civil engineers and architects may find an increasing demand for flood resilient building designs, such as buildings on stilts and floating houses<sup>23</sup>. This is likely to be forced on property owners by the insurance industry, if not by building regulations.

Insurers have been warning of problems for years<sup>24</sup>, and as insurance becomes harder for owner occupiers to obtain in flood risk areas, floodplains are increasingly being used for social rented housing and other “public” buildings.

Insurance research (unpublished) has shown that in England alone:

- 15% of fire and ambulance stations are at risk from flood,
- 12% of hospitals and schools are at risk

89 hospitals and 2,374 schools are on floodplains in England. Over 70% have no flood defences. Hospitals are difficult to evacuate, especially intensive care units, where evacuation could put lives at risk. Hospitals are also important resources during flood events where waterborne pathogens can cause widespread illness.

As mortgage lenders become more risk averse due to the problems of defaulting subprime mortgages, they are likely to look less favourably on flood plain properties as security. Crichton<sup>25</sup> points out that insurance for these will become increasingly uncertain following a recent legal judgement<sup>26</sup>. As repossessions increase or properties remain unsold, ownership of more properties in flood hazard areas may move into the social rental sector. Developers are often obliged as a condition of planning consent (so called “section 106” deals<sup>27</sup>) to build a proportion of “affordable homes”, to be sold to housing associations for rental. The developer knows there will be problems selling properties in flood hazard sites, because without insurance the purchaser will not be able to obtain a mortgage, but there are no such problems with “affordable housing” because this can be sold to a housing association. This will tend to result in even greater numbers of social tenants living in flood hazard areas. Social tenants tend to be the old, the poor and single parent families. In other words, the most vulnerable people in the community will increasingly be forced to live in the most hazardous areas<sup>28</sup>.

Robinson, the chair of the Royal Institute of British Architect’s Building Futures think tank, says that the hitherto widespread practice of allocating and mixing up tenures and cultures does not achieve social resilience<sup>29</sup>. Durable communities are characterised by things which are shared rather than by variety. The usual concession is provision for a community centre or village hall, but is that really enough?

The point is well made: in the past, corner shops, post offices, hairdressers, and other small businesses have helped to provide local employment and social cohesion, but as these disappear, the “pepperpot” policy of mixing tenure and cultures may lead to tension and insularity<sup>30</sup>.

Nature and economics may be changing this pepperpot policy. The boundaries of tenure and culture may in future be determined by the flood hazard and the only factor in common may be the fear of flooding amongst vulnerable people. Community centres may have to be replaced by evacuation refuges.

### **Vulnerable people**

A consultation paper published by the Department of Environment Food and Rural Affairs<sup>31</sup> sets out a government definition of socially vulnerable people as follows:

- *“The elderly (typically over the age of 75) have a higher incidence of disabilities,*
- *Single parent households...,*
- *The less affluent have fewer financial resources for recovery from an event, and are thought less likely to have access to help.”*

Government has been looking at ways to use these various factors to measure social resilience. One approach is to use the Index of Multiple Deprivation produced by the Department of National Statistics, which ranks electoral wards based on an assessment of a mix of economic indicators. Such an index can only provide a very rough indication of where relative vulnerability can be expected. Another approach, widely used in the insurance industry, is to use databases originally designed for providing credit references. For each unit postcode (average 15 households), these can identify the type of resident from a list of more than 50 socio economic categories. They also use databases which have details of building type, value, and age, again by unit postcode. For floods, the insurance industry has access to the National Flood Insurance Claims Database, the biggest flood damage database in the world, much bigger than the flood damage database used by government, with details of the costs of flood damage by up to 28 different factors, including age, value, and type of building, by flood depth, time of year, and velocity<sup>32</sup>. In short, insurance companies have for many years been able to model flood disasters in the UK to a higher resolution and accuracy than government or academia. Despite this, insurance companies are almost never consulted on such issues.

### **Health, age, and disability problems**

The defra definition above does not include the disabled *per se*, who can also be regarded as vulnerable, especially those with impaired senses, mobility, or dependence on electrical equipment, or those living on their own. Local authority Emergency Planning Officers should be building databases of such people to target them for special assistance in the event of a disaster or evacuation. There are Data Protection Act and confidentiality implications of this and it is not possible to simply access the databases used by the National Health Service, council Social Work Departments or the Government’s Department of Work and Pensions. However these organisations could assist by identifying vulnerable people, and seeking their permission to be included in an emergency evacuation target list for local authority emergency planning officers or local authority social work departments. A particular issue can arise with regard to loss or damage to items of great sentimental value such as photographs. Old people may not be willing to leave these items behind in an evacuation. Care homes and sheltered housing in flood hazard areas could be

encouraged to make digital copies of residents' photographs and documents to store in a place of safety.

There are other aspects to social vulnerability to be considered, including insurance and communications, and these are considered below.

Figure 2 shows how these fit in with a risk reduction strategy, but they should be used in combination with action on physical vulnerability such as more rigorous building regulations<sup>33</sup> and more resilient essential infrastructure such as food distribution, drinking water, sanitation, and energy supplies<sup>34</sup>. The final report of the Pitt review of the summer 2007 floods<sup>35</sup> highlighted the growing importance of protecting such critical infrastructure from flooding.

### **Other vulnerable people**

In addition to the old, the sick, children, the disabled, and the poor, other vulnerable sections of society include:

- People dependent on prescription medication or medical equipment.
- Ethnic groups where women may be forced to stay in flooded homes for social or religious reasons when their male relatives are away.
- Immigrants who cannot speak English, do not understand evacuation instructions, and have no friends nearby to help them.
- Schools and homes for handicapped people.
- Mentally ill or agoraphobic people who may lack the will to evacuate.
- Tourists and travellers visiting the country.
- Criminals held in prison where alternative secure accommodation may not be available.
- People suffering from immune suppressant conditions or who are less resistant to infection.
- Residents in dam break inundation areas where urgent evacuation may be necessary<sup>36</sup>.

**Figure 2 . Risk reduction amongst vulnerable people.**



### **Insurance**

Insurance companies can offer risk management advice and financial incentives to reduce risk<sup>37</sup>. They can help people to recover from disasters, and this is particularly important for people with no savings and little income. Insurance companies offer comprehensive policies for only a pound or two payable weekly or fortnightly to help people who do not have bank accounts. Some landlords will collect the insurance premiums along with the rent, or people can pay at the Post Office. Thanks to government support, most social tenants in Scotland have insurance, but in England and Wales only 34 per cent of people in rented accommodation have insurance for their household contents and this may reduce as Post Offices close. It may now be too late for many uninsured people to arrange cover as insurers are increasingly reluctant to accept new business in flood hazard areas at such low rates.

### **Communications and power supplies**

Resilient communications are important not just for finding lost people and directing assistance to where it is most needed. We are dependent on telephone connections to process credit and debit cards; banks have never specified floodproof ATM systems, according to a leading manufacturer<sup>38</sup>.

Communications are critical; consider the following incidents in 2005:

#### January - Carlisle

A severe storm on 8<sup>th</sup> January 2005 resulted in 4,500 homes, schools, and businesses in Carlisle being flooded and 10,000 people made homeless either by flooding or by power cuts. Robertson records that there was a communications blackout as telephones and emergency services' radios stopped working<sup>39</sup>. The warehouse for spare uniforms for police and fire officers was flooded so dry uniforms were not available. Security alarms stopped working as batteries drained. Residents and many business owners reported in focus group meetings that they stayed in their cold, dark, flooded homes or businesses for several nights to discourage looters<sup>40</sup>. Two elderly ladies refused evacuation for fear of looters and died of exposure.

#### June – Yorkshire

When the Boltby dam broke on Sunday, 19<sup>th</sup> June, no warning was given to people downstream. Six people were washed away while picking up litter from the riverbank. Just 12 hours earlier, over 10,000 people, many intoxicated, had been sleeping there in tents after a motorcycle rally. In France, sirens can be sounded to warn of dam breaks, but there is no warning system in the UK. At the time of writing, dam break inundation maps are secret in England with no evacuation plans.

#### July - London

Although this was not a flooding event, it shows how vulnerable communications can be even if they have not been damaged, but are simply congested. On 7<sup>th</sup> July 2005, several terrorist bombs exploded in the heart of the capital. Webb claims that collapse of communications systems was only avoided by preventing some of the calls going through, reducing speech quality to increase capacity, and delaying text message delivery<sup>41</sup>.

#### August - New Orleans, USA

When Hurricane Katrina struck New Orleans on 29<sup>th</sup> August 2005, the city lost virtually all of its communications capability. 3 million phone lines were disabled in the Gulf States by wind and water.

### **Public Health Risks**

The problems of a lack of social resilience amongst certain sectors of society can start to become life threatening when public health is affected. There are four main kinds of effect on public health:

1. direct impacts on physical and mental health,
2. impacts arising from damage to critical infrastructure such as water and electricity supplies.
3. indirect impacts arising from animals including zoonoses and waterborne pathogens.
4. effects of companion animals and livestock on evacuation behaviour.

## Direct Impacts

The direct health impacts of flooding are not widely appreciated and can be hard to measure. Social studies by Middlesex University however, show that the effects can be serious (Table 2).

**Table 2: Physical and mental effects of flooding on survivors.**

Source: extracted from a table produced by Professor Dennis Parker, Middlesex Flood Hazard Research Centre.

<b>Physical effects</b>	<b>%</b>	<b>Mental effects</b>	<b>%</b>
Stiffness in joints	23%	Anxiety during rain	80%
Respiratory illness	21%	Stress	67%
Gastro-intestinal	20%	Depression	56%
Weight loss	20%	Sleep problems	51%
Skin irritations	16%	Panic attacks	27%
Muscle cramps	16%	Anger attacks	24%
High blood pressure	14%	Nightmares	18%
Sprains/strains	14%	Suicidal thoughts	9%
No physical effects	36%	No mental effects	6%

## Damage to Critical Infrastructure

Damage or contamination of drinking water supplies can lead to the spread of diseases. There are also less obvious effects: kidney dialysis machines are dependent on a plentiful supply of pure water for example, hospital hygiene is also dependent on clean water in large quantities.

Many health impaired people are very dependent on the reliable supply of electricity in their homes for comfort, convenience or even survival. There are plenty of examples, ranging from aids for the disabled, to CPAP machines for those with sleep apnoea, not to mention the dependence on electricity for heating systems, including gas central heating. Lack of heat, light and communications in the winter can prove fatal.

## Indirect Impacts due to animals

As Pretty says<sup>42</sup>:

*“connectivity to plants and animals is known to bring many emotional and psychological benefits even to modern humans ... our relationships with animals, whether wild or domestic or indeed pets, also have a significant effect on self-esteem and our feelings of personal identity.”*

Animals, especially pets, can bring comfort, but during a flood they can also bring disease. The diseases that can affect animals and humans are no respecters of national boundaries<sup>43</sup>, and diseases can spread rapidly during times of flooding.

Nearly half of the world's population is infected by vector-borne diseases like malaria, chikungunya fever, West Nile virus, or dengue fever, all dependent on warm temperatures and humidity. Climate change and flooding can increase the risk in the UK. In the meantime there are serious health risks from flooding due to zoonoses and pathogens.

### Zoonoses

Zoonoses are diseases or conditions that can be passed from vertebrate animals to humans. These can vary from country to country. Some countries have diseases such as rabies or heartworm disease, both absent in the UK (so far).

In the UK, floods can release anthrax from the soil; urine from dogs, cattle and rats can spread Weil's disease. Council cut backs on rubbish collection are blamed on the EU Waste Directive<sup>44</sup> and have been followed by a sharp increase in call outs to deal with rat infestations. A leading pest control firm claimed in 2008 that call outs for rodents had increased by 18 per cent in one year in Scotland, and one local authority claims a 50 per cent increase in the Scottish Borders area.

There are well over five million rats in England alone with nearly two per cent of properties affected<sup>45</sup>. There are no official figures for the UK's rat population and estimates range from 15 million to 100 million. A single pair of rats can produce up to 2,000 offspring in a year.

“Pay as you throw” schemes are leading to increased fly tipping which is producing food sources for rats, urban foxes, seagulls and other wildlife. Falkirk council in Scotland has reported that in some areas watercourses now have to be cleared of rubbish on a weekly basis due to fly tipping. Local authorities in Scotland have a statutory duty to clear watercourses, but not in England and Wales where fly tipping could lead to an increased flood risk. Birds such as seagulls and pigeons foraging for food could spread avian flu.

Animals and birds exposed to flood water, hazardous materials, diseases, parasites, or toxins can cause a risk to humans. Pets are often passed among rescuers or cuddled by children.

There are a number of zoonoses found in the UK, for example:

- Anthrax
- Coliform bacteria
- Salmonella
- Campylobacter
- Giardia
- Ringworm
- Borreliosis (also called Lyme disease) from tick bites

- Tick-borne encephalitis (TBE)
- Amyotrophic Lateral Sclerosis (ALS motor neuron disease).
- Weil's disease and dog or cattle leptospirosis
- Bovine spongiform encephalopathy (BSE)
- Creutzfeldt-Jakob Disease (vCJD)

Waterborne Pathogens (see table 3)

Flooding events can spread pathogens from soil into watercourses and reservoirs and subsequently into water supplies especially in warm weather. Organic farming could lead to more E Coli in the soil. Cut backs in refuse collection can lead to more items being flushed down the toilet, leading to sewage pipe blockages and raw sewage overflows. Sustainable Drainage Systems are standard in Scotland, with maintenance responsibilities specified in legislation<sup>46</sup>. These systems can alleviate flooding and pollution, but maintenance responsibilities in England and Wales are unresolved.

Pathogens from overflowing sewers, slaughterhouse waste, animal urine/ faeces or the bodies of dead animals can cause contamination of water supplies sometimes with fatal results. Cryptosporidium parvus in particular is not destroyed by normal water treatment or sewage treatment plants. An outbreak in Milwaukee, Wisconsin in the USA in 1993 made 400,000 people ill and more than 100 died. Possible sources include cattle along the two rivers that flow into the Milwaukee harbour above the water treatment plant, local slaughterhouses and human sewage. Rivers swelled by significant rain and snow runoff could have spread the pathogens for long distances.

Morris states that between 1993 and 2003 there were 4,000 officially recorded incidents of waterborne disease in Britain and that half of these were caused by cryptosporidium<sup>47</sup>. More recent figures are not known, and there is a need for legislation to enforce greater control and monitoring of pathogens. Such legislation has already been passed in Scotland<sup>48</sup>.

**Table 3: Examples of Waterborne Pathogens found in the UK**

<b>Pathogenic bacteria</b>	<b>Parasitic Protozoa</b>	<b>Viruses</b>
Shigella dysenteriae Vibrio cholerae Escherichia coli Vibrio parahaemolyticus Salmonella typhi / paratyphi Campylobacter spp.	Giardia lamblia Entamoeba histolytica Cryptosporidium parvus Toxoplasma Gondii	Hepatitis A and E Rotavirus Norwalk agents

The high incidence of gastro intestinal conditions amongst flood survivors should be of particular concern (see Table 2). Unfortunately the practice of using sandbags during a flood event is still common, and children can often be seen playing in the flood waters or the sand. After a flood, sandbags are contaminated and should be disposed of quickly and safely. Often this does not happen. It is much better to use well engineered temporary flood defences which can later be cleaned properly<sup>49</sup>.

Such devices are already supplied to residents in many flood hazard areas in Scotland.

### Dangerous animals

Mortgage repossessions or flooding can result in companion animals being abandoned. They can then be dangerous to people or other animals and to public health. Modern livestock farming methods mean that cattle are less used to human contact and can be dangerous if approached. Many reptiles and exotic species need handling by people who are qualified and equipped to do so, such as veterinarians from zoos. Some exotic animals are venomous; reptiles can spread salmonella; animal bites can cause injury or disease. Stray dogs may be wary, but owned dogs could be fearless, territorial, and aggressive towards humans and prevent rescuers from entering property. There is a risk of injury from surprising or cornering a dog, intervening in a dog fight, or handling any hungry, injured or sick animal. After flooding from Hurricane Agnes in the USA in 1972, many survivors needed treatment for rat bites as rats joined humans on high ground.

### Livestock

The flooding in 2007 damaged livestock pastures and raised bio-security issues with the escape of the foot and mouth virus from the Pirbright research establishment in Surrey, due in part to the floods which brought the virus up to the surface and helped it to spread. There is a general issue of the difficulties of evacuating large animals such as horses and cattle to prevent pollution of watercourses from drowned animals. If they are unable to reach higher ground on their own, special equipment may be needed. At the River Feschie in Scotland, a sanctuary for rare birds, the RSPB has purchased land on higher ground specifically to provide escape routes and refuges for cattle and sheep grazing by the river.

### Psychological effects

The psychological impact of disasters should not be underestimated (see table 3). According to Hendy<sup>50</sup> of the National Flood Forum, a charity run by flood survivors, the suicide rate in Hull increased dramatically after the June floods there. Keeping animals and their owners together is a way of reducing stress in disaster survivors and consequent increased healthcare costs.

### **Effects of companion animals and livestock on evacuation behaviour.**

With one million horses, seven million cats and seven million dogs, the UK is a nation of animal lovers, spending £1.7 billion a year on pet food. According to pet insurer "esure", dog owners typically spend between £25,000 and £50,000 on their dog during its lifetime. The average pet insurance claim per condition for the biggest pet insurer is £715 for dogs and £501 for cats, figures that have almost doubled in the last five years. Yet there has been little research on the question of the influence of pet and livestock ownership on evacuation behaviour in the UK. The results of such research in the USA show that pet ownership can have a significant effect on evacuation. At the time of writing the authors are planning to undertake a survey to gather information about the evacuation experiences of pet and livestock owners after the floods in England in June and July 2007.

Professor Heath at Purdue University, Indiana, USA, has carried out extensive research on the evacuation behaviour of pet owners in the USA<sup>51</sup>. Experiences in the UK may well be different, because while only 50 per cent of US residents are insured, around 94 per cent of homeowners here have comprehensive insurance cover which includes the costs of alternative accommodation. For serious flooding claims the insurer may provide a static caravan which means that pets can stay with the family. The main problems will be for people who are uninsured, for example, the social tenants described earlier in this paper. This is all the more reason for them to be encouraged to buy insurance.

#### Management of pets and their owners in disasters

Heath found that the main threats to public health from pet ownership in disasters are:

- Pet owners who fail to evacuate
- Pet owners who evacuate without their pets and later try to rescue them
- Mental stress arising in owners separated from their pets.

Purdue University researchers studied human behaviour after mandatory evacuation from flooding in Marysville, California in January 1997. They compiled details of 400 disaster survivors. The overall evacuation rate was 80%. Of the persons who failed to evacuate, nearly 80% owned pets. For 7% of pet owners the primary reason for not evacuating was the pets.

- 30.5% of human evacuation failures could be attributed to dog ownership.
- 26.4% to cat ownership.

In Weyauwega, Wisconsin there was a train derailment in 1996 and burning propane tank wagons were at risk of exploding. There was a compulsory evacuation of the entire town for 18 days. Approximately one third of pet owners took their pets with them, one third evacuated without their pets then attempted to rescue them and one third left their pets in their homes for the entire 18 days. Many who rescued pets did so in defiance of evacuation orders and at great risk to themselves.

The main lesson from Heath's research is that emergency planners should allow pet owners to evacuate with their pets and should provide appropriate transport, accommodation, cat carriers, bird cages and small animal boxes.

Reducing animal diseases is a way of improving public health resilience. Low income pet owners in flood hazard areas in the UK are less likely to have microchip identification of pets, or contingency plans for boarding arrangements in case of evacuation, or to train their dogs to behave well with unfamiliar people. Cat owners may not have a cat carrier to transport their animals. Low income groups are also less likely to vaccinate their cats against feline distemper or their dogs against parvovirus and corona virus diarrhoea, distemper, or leptospirosis. Their animals will also face an increased risk of internal parasites and flea infestations. Low income farmers may not have vaccinated cattle against leptospirosis which can then appear in unpasteurised milk used by the farmer and his family. Once again the most vulnerable people will be at greatest risk.

#### **Conclusions.**

Social resilience could be improved by:

1. Planning policies which prevent residential development in flood hazard areas.
2. Grants for natural flood management and sustainable flood management projects.
3. Regular consultation at local and national level with insurers and other key stakeholders to keep insurance available and affordable.
4. Higher resolution Index of Multiple Deprivation.
5. Flood resilient Building Regulations.
6. Target lists of people requiring special assistance during an evacuation.
7. Encouragement of insurance with rent schemes.
8. Mobile phone stations and other critical infrastructure not permitted in flood hazard areas.
9. Regular reports required from local authorities on all flood events in their area and actions taken to prevent a recurrence.
10. Statutory duties to clear watercourses and drains and maintain sustainable drainage systems.
11. Allowing local authority emergency planners, police, and rescue services to access secret dam break inundation maps so that evacuation plans can be prepared.

All of these measures have been introduced successfully in Scotland<sup>52</sup> .

Abandoned pets and livestock can contribute to health problems after a flood. Better treatment of pets and livestock in an emergency could have a significant beneficial effect on the resilience of our society both in terms of disease control and emotional resilience.

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