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Flood Resilience Community Pathfinder Evaluation

Rapid Evidence Assessment

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A report of research carried out by Collingwood Environmental Partnership, on behalf of the Department for Environment, Farming and Rural Affairs

Authors: Twigger-Ross, C., Kashefi, E., Weldon, S., Brooks, K., Deeming, H., Forrest, S., Fielding, J., Gomersall, A., Harries, T., McCarthy, S., Orr, P., Parker, D., and Tapsell, S (2014) Flood Resilience Community Pathfinder Evaluation: Rapid Evidence Assessment. London: Defra

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Executive Summary

Introduction

The increase in the risk of flooding as a result of extreme weather and climate change makes it essential for local authorities and communities to engage with this issue. Defra is providing grant funding to 13 local authorities throughout England under a new Flood Resilience Community Pathfinder (FRCP) scheme aimed at stimulating community action to increase resilience. The measures being developed include property-level protection, flood resilience groups, volunteer flood wardens and community champions, engagement with more vulnerable groups and efforts to increase financial resilience.

Collingwood Environmental Planning (CEP) and a consortium of expert project partners are conducting the evaluation of the Pathfinder scheme. Evaluating policy interventions like the FRCP scheme generates valuable information and contributes to a reliable understanding of which actions work and are effective.

Rapid Evidence Assessments (REA) or systematic reviews are integral to evaluations (HM Treasury, 2011) to provide the conceptual framework. They have been developed in the context of the rapid growth in quantity and availability of evidence specifically via electronic databases, together with the demand in government for transparency and accountability within evidence gathering (JWEG, 2013).

REAs involve a systematic search for relevant literature guided by experts, based on:

- Clear criteria for inclusion and exclusion of documents and studies
- Measures of quality of research

This report provides details of the process and findings of the REA conducted for FRCP evaluation.

Aims and purpose of the REA

The overarching purpose of a REA is to review the best available research evidence on a topic to contribute to effective policy making. An REA is shorter and quicker than a systematic review, which is a tool which has a clearly defined set of objectives, a set of criteria to include/exclude evidence, a transparent, replicable methodology and a formal appraisal of evidence using agreed quality criteria. This means that the evidence gathered in an REA is not as comprehensive or exhaustive as a systematic review, and the findings in this report need to be interpreted in this light.

For the evaluation of the Pathfinder scheme, the REA provides evidence to inform the parameter measures of resilience and a comprehensive review of relevant literature with a wider scope than this project.

The REA will inform the evaluation framework and criteria of the Pathfinder scheme-level evaluation and support the pathfinder project leads to improve and develop their own

evaluation criteria by clarifying what resilience, and more importantly, what a change in resilience, looks like in practice.

Key points

What does resilience mean in the context of flood risk management as whole?

The term "resilience" has entered into common use within the world of disasters in general over the past two decades and gained increased prominence after Hurricane Katrina in 2005. DFID (2011: 6) provides a useful definition of resilience, from a disaster perspective:

> *Disaster resilience is the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses – such as earthquakes, droughts or violent conflict – without compromising their long-term prospects.*

The REA focuses on the social aspects of resilience largely because this is the focus of the Pathfinders, but also because this is perhaps a less well developed aspect of resilience. There has been a good deal of clear conceptual work to develop frameworks of resilience for disasters in general, and flood risk management in particular, drawing on case studies and qualitative work. The resulting models remain largely descriptive as they have not been tested or refined empirically to the point where they might gain predictive power.

DFID's (2011: 6) resilience framework frames resilience as a process and asks the key questions: "What is the focus of resilience?" and, "What is the stress or shock?" that "countries, communities and households" are being resilient to. For the Pathfinders, the "shock" is flooding and resilience is focussed at a number of sub-national levels: some are aiming to influence county wide, some are focussed at the level of geographical communities, and some are targeting specific communities of interest.

Twigger-Ross *et al.* (2011) provide a useful overview of the concept of resilience in relation to emergencies. They use a definition articulated by Whittle *et al.* (2010) from their work in flood risk and drawing on others (Pelling, 2010, Watson *et al.*, 2009; Medd and Marvin, 2005) and this is presented in Box 1 below.

Box 1

Definitions of resilience (Twigger-Ross et al., 2011)

Resilience as resistance – holding the line, preparing for the last disaster. This is useful when it prepares people for a hazard: e.g. flood gates on houses but not so useful when the hazard is not as anticipated: e.g. overtopping of flood defences that overwhelms flood gates and no plan for evacuation

Resilience as bounce-back – getting back to normal…. pretending it hasn't happened. Useful in terms of an optimistic rhetoric. Not so useful because it can be unrealistic and can lead to reproduction of vulnerabilities.

Resilience as adaptation – adjusting to a new normal…accepting that your world has

changed which should ensure that vulnerabilities are not reproduced. Can be hard for people to accept living with hazards

Resilience as transformation owning the need to change……transforming to meet future threats Radical change (physical, social, psychological, economic) in the face of current or future hazards owned by individuals and communities (of all types).

Here we see a change from a focus on "resistance" to a more proactive approach to "adaptation", along with a move from a vulnerability focus to a resilience focus which can be seen as a paradigm shift to approaching risk within the disaster field (ENSURE, 2009).

This way of discussing resilience ensures that it is made sense of as a dynamic process, to be considered:

> *…in terms of relationships and processes rather than as a static characteristic of an individual, household, public service or community. In other words, resilience is not so much a response to the flood hazard itself, but is an emergent characteristic of the way in which the flood response and the subsequent recovery process are managed* (Whittle *et al.*, 2010:12).

Capacities / resources for building resilience

Another approach to resilience focuses on "capacities" or "resources" for resilience. This refers to those capacities across a number of domains that exist within a system before an emergency and will be drawn upon during an emergency. They provide the foundation for resilience within the disaster/emergency situation. Response is built using pre-existing community capacities, which are expanded or extended in line with a – perhaps dramatically – identified need (Dynes, 2005). Cutter *et al.* (2010: 6) develop indicators around the following five aspects with a focus at community level: social, economic, institutional and infrastructure resilience, community capital.

The relationship between vulnerability and resilience

Research shows that there are certain characteristics that make people more likely to suffer negative impacts of flooding. We call those vulnerability characteristics. The focus on vulnerability highlights the issue of inequalities and how they are played out in the context of disasters and emergencies. This leads to a consideration of environmental justice and an understanding of the more systemic societal issues.

A further key issue for resilience is ensuring that pre-existing vulnerabilities are not reproduced through the recovery process. One key issue with the conceptualisation of resilience as "getting back to normal" is the danger that "normal" will mean the continuation of vulnerabilities.

What does resilience mean at an individual, community and society level in relation to flood risk management?

Clear suggestions emerge from the literature as to how community resilience to flooding is created. Firstly, resilience to flooding is inextricably linked to capacities, capabilities, processes that exist on a day to day basis within a community. This "inherent resilience and vulnerabilities" (Cutter *et al.*, 2008) forms the basis for resilience to flooding and other emergencies. However, it is also clear that there are specific capacities that are needed in

order to be resilient to flood risk, from knowledge of flood risk, actions to take in a flood, development of emergency plans through to longer term planning of settlements that can mitigate flood risk.

The ENSURE project identifies three key dimensions of resilience: robustness, adaptability and transformability. These dimensions need to be developed in each of the different resilience domains described by Cutter *et al.* (2010): social, economic, infrastructure, institutional and community capital. Taking a systems approach to flood risk management means that all these aspects will need to be included in resilience building.

Building the capacity for resilience to flooding needs both formal and informal structures and processes and importantly requires clear linkages and accountability between those structures, so that resources can be freely transferred and exchanged. Community resilience cannot be built in a vacuum.

Secondly, floods themselves provide opportunities to create resilience; the emergence of groups, structures and activities is clearly illustrated by the examples of Great Yarmouth, Thirlby and Hull. What is important is translating those temporary relationships into longer lasting resilience. This points to the dynamic nature of resilience and emphasises the need to develop processes of resilience rather than seeing resilience as an outcome that is achieved once and never needs to be re-addressed. Research suggests that creating resilience to flooding is an ongoing process of adaptation and learning from past events and preparing for future risks.

Finally, discussions of resilience lead to a more general question about how we develop sustainable communities:

"It may even be advantageous to widen the scope beyond resilience, and to advocate strengthening communities for a whole range of reasons, or alternatively, to incorporate civil-protection focused resilience building into ongoing community-focused activities (e.g. 'Transition Towns' groups). This could bolster people's desire for local community solutions by highlighting the potential 'emergency situation' benefits to locally based groups, who get together for a variety of other reasons (e.g. to make improvements to local area or to improve local networks), because it has the potential to increase community safety through local people knowing each other's vulnerabilities, resources and skills" (Twigger-Ross *et al.*, 2011: 35).

What is known about interventions to build resilience to flood risk management?

The REA reports on research that has been carried out to explore new ways of approaching flood risk management, which we have termed as interventions. Whilst these are not interventions in the traditional scientific meaning, they are interventions in the sense that they are attempting to create new ways of practising flood risk management, involving key stakeholders and creating new knowledge. We also report on research that highlights barriers to resilience.

Risk perception and preparedness

A number of studies highlight the implications for designing interventions to increase risk awareness, preparedness and action. For example, Bradford *et al.* (2012: 29) conceptualise risk perception as a "pillar of social resilience" meaning that understanding

how people perceive risk is important for the development of risk communications that are trusted and acted upon by individuals so as to improve their resilience to floods. Their quantitative research found no statistical relationship between awareness and flood preparedness or between worry and preparedness. Another study by Soane *et al.* (2010: 3035) concluded that risk perception only leads to property level protection if homeowners have a sense of responsibility and agency and believe that their efforts will be "worthwhile."

A problem highlighted by other studies is a lack of clarity regarding the roles and responsibilities of agencies engaged in flood risk management. Deeming *et al.* (2012) suggest that the issue derives from the many decades of flood hazard management that preceded flood risk management (FRM) (Johnson *et al.*, 2005), when it was understood that 'the powers that be' could always tame errant hazards, a philosophy that could be argued to have led to society's sustained encroachment onto the floodplain. This narrative, they suggest, allowed the hazard-exposed publics to develop a 'trust in authority' which is still effectively preventing them from engaging fully with the new flood risk management paradigm.

Further evidence is provided by Harries (2013) of the low take-up of measures to increase resilience by those who were aware of being at risk of flooding or had actually experienced flooding (Thurston *et al.*, 2008) and by Lo (2013) who found no statistical relationship between uptake of insurance and risk perception, experience of flood damage or perceptions of affordability in a study in Australia. The only factor found to be of statistical significance was social expectation.

The role of expertise, collaborative learning and bringing stakeholders together

Given the variety and complexity of issues around risk perception and risk preparedness it is useful to look at approaches aimed at increasing community resilience that go beyond conventional (one way) methods of risk communication and are based on engaging communities through dialogue and discussion.

Several recent studies (Ashley *et al.*, 2012; Evers *et al.*, 2012; McEwan and Jones, 2012; Cashman, 2009 and 2011; Lane *et al.*, 2011; Callon, 1999) report on new attempts at developing strategies and methodologies for opening up flood risk management, challenging the traditional positioning of flood risk 'expertise' as solely the domain of science and scientists. These studies report attempts to harness this potential by enabling the co-production of knowledge between by scientists, key institutional stakeholders and the public. One of the reasons this is significant in terms of developing individual and community resilience is that local knowledge can contribute to more accurate and effective mapping of, and in some instances more economical solutions to, flood risk at the local level.

One specific issue looked at in relation to creating resilience is insurance. Insurance can be an aspect of resilience, a barrier to resilience or a factor promoting resilience. For example, Deeming *et al.*'s (2012) paper on recovery following the 2007 Hull floods highlighted how access to the resilience provided by insurance is sometimes restricted. In the present market, insurers tend to respond to a flood either by increasing a customer's premiums or excess level which could render insurance unaffordable and encourage some householders to opt out of flood insurance altogether. It is also possible that those with effective and affordable insurance against flood losses will be less inclined to take practical adaptation measures because they know they can rely on the cover provided by their insurers.

Deeming *et al*.'s research also illustrates how insurance can deter the adoption of other resilience measures, for example because of the insistence by insurance companies on like-for-like restoration which prevents the use of more flood resilient techniques. Although this experience is not untypical, it is also possible for insurance and insurers to promote resilience, as reported by Harries (2010).

How is resilience measured? What metrics exist for measuring resilience?

The review process identified a range of academic literature that specifically addressed the issue of measurement of community resilience and social vulnerability to natural hazards such as flooding. The object and subject of measurement vary considerably. However, in all studies there is recognition of the complexity of the social and economic factors, the problems associated with defining both resilience and community, the difficulty of evaluating the changing dimensions of community resilience over time and the huge challenge of developing useable indicators to map these dimensions in a coherent manner. Nonetheless, the measurement, or indication, of community resilience is desirable in helping to develop effective interventions, practices and policies for flood risk management and to build resilient communities.

Measuring social vulnerability and resilience

Cutter *et al.* (2010) developed and used a Social Vulnerability Index (SoVI), based on a well-known method of identifying social impacts. It is an algorithm that has been developed using a statistical method and can be combined with traditional cost-benefit analysis to produce a context-based result. The term social vulnerability is used broadly to include both social and economic factors. This study argues that an understanding of the differential impacts of hazards such as flooding, as a product of social vulnerability, is a crucial element in formulating more effective FRM.

Other methods of modelling social vulnerability (see Zahran, 2008) have used deductive quantitative modelling techniques to link geographical localities that are characterised by a high percentage of vulnerable communities with higher than expected casualties due to flood events. However, it is important to note that different methods can often produce different results.

The ENSURE (2011) project presents a 'vulnerability and resilience framework tool' that indicates the relationship between vulnerability and resilience but also brings together the time and space dimensions of a flood hazard cycle.

Djordjevic *et al.* (2011) argue that there are compelling reasons for quantifying the cost-effectiveness of resilience measures and FRM plans since this is the most direct way to inform more universal and scientifically sound policies and plans. However, the dilemma faced in identifying a common set of preferably quantifiable indicators against the more complex socio-economic variables inherent in the evaluation of resilience in communities, has resulted in the majority of studies using a range of both quantitative and qualitative methods.

Capturing community resilience

It is generally agreed that the concept of community resilience is difficult to assess and 'operationalize', not least because it is such an ambiguous concept that different

disciplines have different ways of characterising and there is a lack of reliable tools and assessment methods to capture the relevant aspects of the ways in which communities interact and change.

Based on the 'Capacity for Change' (C4C) LEADER programme in Dumfries Scotland, Steiner and Markantoni (2013) have developed an evaluation model to explore resilience at individual and community level. A significant contribution of this study is that the proposed model enables the measurement of resilience in qualitative and quantitative ways which, if applied in a longitudinal study, could compare different dimensions of resilience between communities over time.

In a paper based on US case studies, Ewing and Synolakis (2011: 1) outline their development and use of a Community Resilience Index (CRI) based on lessons learned from recent storms and coastal flooding. Their principle argument is that, *"a community resilience index can help communities recognize their resilience, strengths and opportunities for improvement.*"

Conclusions

The way resilience is framed will lead to different actions and emphases. Given the predicted increase in floods and rainfall in the context of climate change, the focus on physical structures and resilience as resistance has been shown to be unsustainable. Floods are predicted to be not only more frequent but also more unpredictable (Defra, 2012b) and call for strategies and actions that can cope with uncertainty and are not only robust but also adaptable.

The evidence shows that floods become a hazard with negative impacts because of the inextricable link between physical processes and social systems. Definitions of resilience to guide policy and practice need to be sufficiently nuanced so as to incorporate this complexity and to help provide practical ways through it.

Much of the interesting resilience thinking is being developed in the context of disasters in general on the one hand and adaptation to climate change on the other hand, rather than in relation to flood risk in particular which is a further reason why these definitions and theories need more testing.

Overall, the evidence is still rather a patchwork of findings, many of which are not framed within a resilience approach, yet clearly are central to understanding and developing resilience.

There is considerable evidence about individual risk perception/awareness/actions in relation to flood risk which can be fitted into the characteristics approach of Cutter. Here risk perception/risk actions are seen as part of building "institutional" resilience whilst PLP and other physical measures are part of building "infrastructure" resilience. Flood action groups build both community capital and institutional resilience. At this individual level the evidence shows us that the relationship between awareness and action before during and after a flood is complex.

In relation to the community level there is evidence around the relationship between the nature of the community and types of resilience, with the suggestion that networks are of central importance, in terms of both close ties within communities and looser links between members of communities and more formal organisations. Links between people can be

seen as resources which can be drawn upon during floods, for example through bringing people together to draw on local knowledge and to empower people to help solve flood risk management issues. It is also necessary to consider how governance structures for flood risk management are resilient

Getting to grips with definitions of resilience is a key starting point to be able to measure resilience. The importance of baseline data is also highlighted together with caution attached to over generalisation of findings and the need to understand each situation as a constellation of resilience factors that come together in ways that are unique to each situation. Work on indicators and qualitative measures of resilience using agreed definitions are in infancy.

There is a lack of formal evaluation of 'interventions'. Firstly, there is a lack of evidence around policies, and practical actions that have been intentionally carried out with a specific view to improving resilience. Secondly, where there have been those interventions, they have not been formally evaluated.

Flood risk resilience is an emerging, interdisciplinary area of study as discussed earlier and as such has not moved into a more hypothesis testing phase of work although in some areas there is that tradition (e.g. attitude-behaviour research) which could be drawn on.

Related to the point above, flood risk resilience, by its nature and because it is dealing with complex socio-technical systems, requires a range of disciplines. We suggest that this needs to be fully discussed in relation to REA methods to understand how quality can be assessed across disciplines so that robust studies are used for evidence reviews.

Relevance to the Flood Risk Community Pathfinders

Resilience needs to be understood as complex and multi-faceted. For the Pathfinders it will be important to try to pinpoint which aspects of resilience they are targeting with their interventions and to develop measures to assess their effectiveness.

In terms of useful learning with respect to interventions, the review reinforces the complexity of the relationships between awareness and action, both of which are important aspects of resilience but do not have a linear relationship. Interventions based on community engagement, dialogue and learning seem to provide most promise in terms of improving resilience to flood risk at the community level.

Finally, it is vital to highlight that community resilience is only one aspect of the socio-technical system that is flood risk management. Developments in spatial planning, land management, flood defences, sustainable water management are other vital aspects of the system. It will be important ensure that findings from the Pathfinders are situated alongside other developments towards flood risk resilience in the UK.

1. Introduction

The current context of Flood Risk Management (FRM[1]) within the UK is one of shifting responsibilities to the local level through a number of governance mechanisms that have been implemented since the Pitt Review in 2007 (Pitt, 2007), through the Floods and Water Management Act 2010. A key change associated with this was the creation of Lead Local Flood Authorities (LLFA) who are tasked with the development of strategy for FRM in their areas and for maintaining a register of flood risk assets. They also have lead responsibility for managing the risk of flooding from surface water, groundwater and ordinary watercourses. As well as this clear devolution of responsibility to the local level for strategy and management of floods, there have been significant developments with respect to funding. In 2011 Defra announced a new partnership approach to funding for FRM which aimed to "*allow more schemes to go ahead and to give each community more of a say in what is done to protect them……Instead of meeting the full costs of just a limited number of projects, the new approach could make Government money available towards any worthwhile scheme over time*" (Defra, 2011: 1).

In addition, as Nye *et al.* (2011) highlight, there has been a significant move within UK flood risk management towards the recognition of the value of social aspects of flooding specifically community engagement and community level-responsibility:

> *The discussion to this point reveals a fairly significant 'social turn' in UK FCRM in the past two decades, away from an emphasis almost solely on structural flood defence measures and towards an understanding that social and institutional processes including community engagement, and community-level responsibility have an important, non-structural role in helping people to live with flooding and to make communities more resilient to the impacts of flooding when it occurs (*Nye et *al.,* 2011: 292*).*

Defra has recently commissioned 13 Flood Risk Community Resilience Pathfinder projects which are focussed on improving flood resilience at the community level via financial, property level, and community resilience measures. The Pathfinder projects are all led by LLFA but in partnership with the National Flood Forum, the Environment Agency and local community groups. The aim of the Pathfinder initiative is to understand what factors build resilience at the local level and to assess the benefits of alternative partnership models and approaches. This latest project is further support for the proposed shift in policy. This current set of activities at the local level is complemented by the structures set up to manage emergency planning, specifically the Regional and Local Resilience Fora which were put in place by the Civil Contingencies Act 2004. What this provides is a structure, into which community resilience planning by LLFA can feed into wider regional and national initiatives.

CEP is leading the consortium carrying out the evaluation of these Flood Community Resilience Pathfinders (FCRP) for Defra. The CEP consortium includes: the Flood Hazard Research Centre at Middlesex University (Sue Tapsell, Prof Dennis Parker, Dr Simon McCarthy); the University of Surrey (Dr Jane Fielding); Northumbria University (Dr Hugh Deeming); the Centre for Evidence and Policy at King's College London (Alan Gomersall);

[1] We use the general term Flood Risk Management (FRM) to refer to the whole flood risk management cycle, both policy and practice.

nef consulting Limited (Olivier Vardoulakis); and CEP Associates: Dr Elham Kashefi, Dr Sue Weldon, Dr Tim Harries, Yvonne Rees and Ruth Johnston.

Evaluation of policy and policy interventions has become an important tool within UK Government with specific guidance on its approach developed in the Magenta Book (HM Treasury: 2011). A key part of evaluation is the development of the conceptual framework which in turn requires a review of relevant evidence. As part of the FRCP Evaluation project, Defra has commissioned this Rapid Evidence Assessment (REA) to inform the development of the evaluation framework and also to provide an evidence base on the issue around improving resilience to flooding at the local level.

This report is the REA report for the Flood Community Resilience Pathfinder Evaluation.

It provides the following:

i) Overview of the aims of the REA in general and the research questions addressed in this report (Section 2)

ii) Description of the REA method (Section 3)

iii) Summary of the evidence found through the REA method (Section 4)

iv) Analysis of the evidence found in relation to the key research questions (Sections 5 – 7)

v) Discussion and conclusion (Section 8)

2. Rapid Evidence Assessment (REA) Aims and Research Questions

Aims of the REA

The aims of the REA are the following:

i) To provide evidence to inform the parameter measures of resilience in this evaluation; and

ii) To provide a comprehensive review of relevant literature with a wider scope than this project.

The areas of literature relevant to the research questions listed in the specification are numerous and dispersed across disciplines covering sociology, psychology, disaster management, anthropology and environmental studies. This is partly due to the definition of resilience, which has been used across many different areas of studies. It is also to do with the types of interventions that are proposed by the Pathfinders which range from physical measures through to social and financial measures, including: property level protection (e.g. flood doors, smart air bricks); awareness raising activities (e.g. school education packs, information boards); engaging volunteers in FRM (e.g. training flood wardens, developing community flood forums, flood action groups, "gully watch", monitoring of rivers); developing community resilience/response plans; improving flood warning/forecasting capabilities (e.g. local telemetry, installing river gauges); land management risk reduction measures; and improving financial resilience (e.g. encouraging and supporting uptake of insurance in deprived areas).

To guide the REA and the evaluation, the project started with a conceptual framework drawing on the following working definition of community resilience in emergencies as follows:

> *Communities (social, spatial, cognitive) working with local resources (information, social capital, economic development, and community competence) alongside local expertise (e.g. local emergency planners, voluntary sector, local responders) to help themselves and others to prepare and respond to, and to recover from emergencies, in ways that sustain an acceptable level of community functioning* (Twigger-Ross *et al.*, 2011: 11).

This definition draws on the work of Whittle *et al.*, (2010), Pelling (2010) and Norris *et al.* (2008). The definition of resilience is discussed in more detail in Section 5, what is presented here was the starting point in terms of the resilience concept and operationalization for this project. What is important about this definition is that is recognises that resilience in emergencies is inextricably linked to the resources communities have to draw upon in their day to day functioning. The discussion in Section 5 provides a more nuanced perspective on this definition, putting it into a systems approach to flood risk management and highlighting key characteristics of a resilient system.

We hypothesise that the Flood Resilience Community Pathfinder interventions are aimed at improving these capacities in the context of flooding so as to improve overall resilience. Since starting the project we have added to this conceptual framework drawing on the

more recent work of Cutter *et al*[2]*.* (2010). In their review of baseline indicators for disaster resilience they categorise the "adaptive capacities" in the following way:

i) Social resilience;

ii) Economic resilience;

iii) Institutional resilience;

iv) Infrastructure resilience;

v) Community capital.

In relation to the REA we have used the Cutter *et al.* (2010) framework to help in ordering some of the literature, but also held it up for interrogation alongside other frameworks that have been developed and as such it is further discussed in Section 5.

Research questions

The research questions for the REA underwent some development before the search process began. The original questions set out in the specification for the piece of work were developed and refined with the project board and the experts on the project team[3] (see Interim Research Outline Report (2013) for details). They were further refined as the evidence was reviewed.

The refined research questions are presented in the table below. Within each main question there were sub-questions which were linked together as felt appropriate. The second column shows on where and how the questions are addressed in the review.

Table 1: Refined research questions

Questions	Where and how addressed in the review
1. What does resilience mean in the context of Flood Risk Management as a whole (preparing, responding and recovering from flooding)?	Section 5: This section has focussed on understanding the range of definitions of resilience drawing on those based on empirical research
1a. What does it mean at an individual, community and society level in relation to flood risk management?	Section 5: In the review we have drawn out the different levels of individual, community and societal of resilience in relation to FCRM
1b. What does financial resilience mean in relation to flood risk management?	There were very few papers specifically in the search around the aspects of insurance in relation to flood risk resilience (which was a focus raised by the project board for financial resilience). The lack of papers is reflected in our review. Further, it was felt that the flood synthesis project[4] was examining questions around insurance so it

[2] We have used the domains suggested by Cutter et al (2010) in two ways, firstly, to frame data collection for the evaluation so that all the Pathfinders are collecting data across the domains to enable us to have comparable data, to some degree, across the Pathfinders. In addition, we are using the domains to categorise the activities or interventions designed by the Pathfinders.

[3] The Interim Research Outline Report was an internal document for Defra and is available from CEP or Defra on request

[4] The Defra Flood Social Science Synthesis project

Questions	Where and how addressed in the review
	was not pursued in Section 5. Some information on the topic of insurance is in Section 6 on interventions where it is relevant. We acknowledge that the brevity with which we have examined insurance issues is in no way a reflection of the importance of these issues in the debates on flood risk resilience. It is an area for future consideration that needs examining with a remit beyond flooding to draw in insights from other areas of insurance and also linking to the wider issue of economic resilience which, for similar reasons, we also did not examine in detail.
1c. What does social resilience look like in practice? Are there examples of resilient communities? Drawing on findings from previous research questions (e.g. governance, scale)	Section 5: The section provides some case examples of "resilient communities" with the focus on the social aspects of resilience.
2. What is known about the "source" of resilience, i.e. how it is "created" or built in the context of flood risk management? (main question)	Section 5: In this section we have made some observations that come from the review and in Section 6 are papers where some of the approaches have been tested.
2a. What are the links between (social) resilience and vulnerability in the context of flood risk management?	This is a key question which has quite a debate around it within the literature and as such a flavour of that debate is given in Section 5 with references for follow up as appropriate
2b. What is the relationship between behaviours and resilience in the context of flood risk management?	Section 5: This is addressed in Q1 through the individual, community or societal level
2c. Does individual or shared ownership and responsibility with regard to flood risk, build resilience?	This is a question that has some evidence around it which is discussed in Section 6 but this also links to factors that create resilience in Section 5.
2d. What role do institutional and governance arrangements play in building resilience in the context of flood risk management?	This is addressed in Section 5 in the section on what does resilience look like at the societal level
3. What is known about interventions to build resilience at a society, community and individual scale, and their effectiveness in relation to flood risk management?	Section 6 reports on papers that have carried out practical approaches to building resilience. As will be seen there was little to no evidence of fully evaluated interventions. This section focussed only on flood risk management examples and with an emphasis on building community resilience.
4. How could you measure resilience in relation to flood risk management?	Section 7 reviews work on how resilience has been measured drawing on both evidence focussed on wider resilience to disasters as well as in the context of flood risk management
4a. What metrics exist for measuring resilience?	Section 7 as above

Choosing a focus for the REA

What was clear from the discussions with our experts and the project board was that the number and type of research questions were a) too numerous and b) not entirely appropriate for the REA process. The purpose of a Rapid Evidence Assessment is to review the best available research evidence for effective policy making. Usually this concerns an evaluation of an intervention. Evaluating interventions in the areas of health or crime research seem to point to obvious outcome variables (the efficacy of treatments/ crime statistics), but in assessing the impact of interventions to increase resilience to flood risk does not seem to point to obvious outcome variables.

Research questions 1, 2 and 4 address definitions and measurement issues which are important and need to be reviewed, but do not address the main REA purpose of assessing the research evidence on the effectiveness of interventions to build resilience in the context of flood risk management. For this reason, the in depth focus of the REA is around question 3 on interventions and how this was carried out is reported in Section 4.

3. Rapid Evidence Assessment (REA) Methodology

Overview of the REA

A REA is one of a number of approaches to evidence gathering and analysis. Across UK government it is used in general "*for harnessing and using the best available research evidence for effective policy making*" (REA toolkit Government Social Research (GSR) website, undated). It also has a specific use within the context of UK government policy evaluation. Guidance on evaluation is given by the Magenta Book (HM Treasury, 2011) which sets out for both policy makers and policy analysts the benefits of evaluation, how to make evaluation of interventions feasible together with more detail on the technical aspects of evaluation: key steps in evaluation, how to design evaluations and how to interpret findings. The role of the REA is to develop the conceptual framework to be used in the evaluation. To fill this role the REA should:

> *…provide a balanced assessment of what is already known about a policy or practice issue, by using systematic review methods to search and critically appraise existing research. They aim to be rigorous and explicit in method and thus systematic but make concessions to the breadth or depth of the process by limiting particular aspects of the systematic review process. The speed at which this is undertaken will depend on how quickly the evidence is needed, the available resource to carry out the REA and the extent to which reviewers are prepared to limit the systematic review process* (REA toolkit, Government Social Research (GSR) website, undated).

As highlighted in the quote above, REAs use a shorter version of the "systematic review process". A systematic review is a tool which has a clearly defined set of objectives, a set of criteria to include/exclude evidence, a transparent, replicable methodology and a formal appraisal of evidence using agreed quality criteria. As the Magenta Book (HM Treasury, 2011: 61) states:

> *Systematic reviews therefore differ from other literature reviews by following an explicit protocol for identifying and assessing relevant studies. For instance, the protocol might specify what reference databases were searched, what search terms were used, and what criteria were used to filter studies and select those for detailed review. In general, the review of those studies which are selected will be qualitative (although systematic review can be combined with other evaluation techniques, such as meta-analysis).*

Systematic reviews and REAs have been developed in the context of the rapid growth in quantity and availability of evidence specifically via electronic databases, together with the demand in government for transparency and accountability within evidence gathering (JWEG, 2013).

As noted above, an REA is shorter and quicker than a systematic review and Box 1 below provides the GSR advice on an REA will be "rapid" and when it is good to use an REA.

Box 1

REA

How will it be rapid?

There are a number of aspects of the systematic review process that can be limited in an REA to shorten the timescale. There is no requirement for all stages to be limited.

The REA question – if the question is broad the search needs to be further limited.

Searching – consider using less developed search strings rather than extensive search of all variants; if there are many existing recent reviews, and then consider a review of reviews rather than of primary studies.

Screening stage – REAs can use 'grey' and print sources but less exhaustively than systematic reviews. It is possible to only use electronically available abstracts and texts but this is unadvisable because of the increased risk of bias.

Mapping stage – if included at all; often has to be limited in terms of the breadth of the initial evidence map.

Data extract only on results and key data for simple quality assessment.

Simple quality appraisal and/or synthesis of studies.

When is it good to use an REA?

Rapid Evidence Assessments can be undertaken in the following circumstances:

When there is uncertainty about the effectiveness of a policy or service and there has been some previous research.

When a policy decision is required within months and policy makers/researchers want to make decisions based on the best available evidence within that time.

At policy development stage, when evidence of the likely effects of an intervention is required.

When it is known that there is a wide range of research on a subject but questions still remain unanswered.

When a map of evidence in a topic area is required to determine whether there is any existing evidence and to direct future research needs.

As a starting point. Ideally, one is undertaken to answer a particularly pressing policy concern, and once the immediate question is answered it can form the basis of a more detailed full systematic review. In such cases, a Rapid Evidence Assessment could be better described as an 'interim evidence assessment'.

In these situations an REA can provide a quick synthesis of the available evidence by shortening the traditional systematic review process".

(taken from the REA toolkit, GSR website http://www.civilservice.gov.uk/networks/gsr/resources-and-guidance/rapid-evidence-assessment/what-is undated, accessed 14/10/2013)

In relation to our REA we have limited our stages by:

i) Refining the research questions and focussing in depth on the question around interventions.

ii) Using inclusion/exclusion criteria to manage our search together with keeping a search string that was purposely restricted: i.e. using flood AND resilience in all searches to reduce the numbers of papers retrieved.

iii) Our “grey” and printed literature was provided by our experts within the project team and where conferences abstracts and unpublished theses were picked up on electronic databases they were excluded from detailed analysis.

iv) Our mapping stage was limited to listing papers in terms of relevance to research question.

v) Our data extraction form and quality criteria were streamlined for speed and only filled in fully for papers used in Section 6.

vi) Our appraisal of studies was confined to within the research questions but was carried out to a high standard of qualitative analysis. Themes were drawn out and interrogated providing an intelligent use of the evidence.

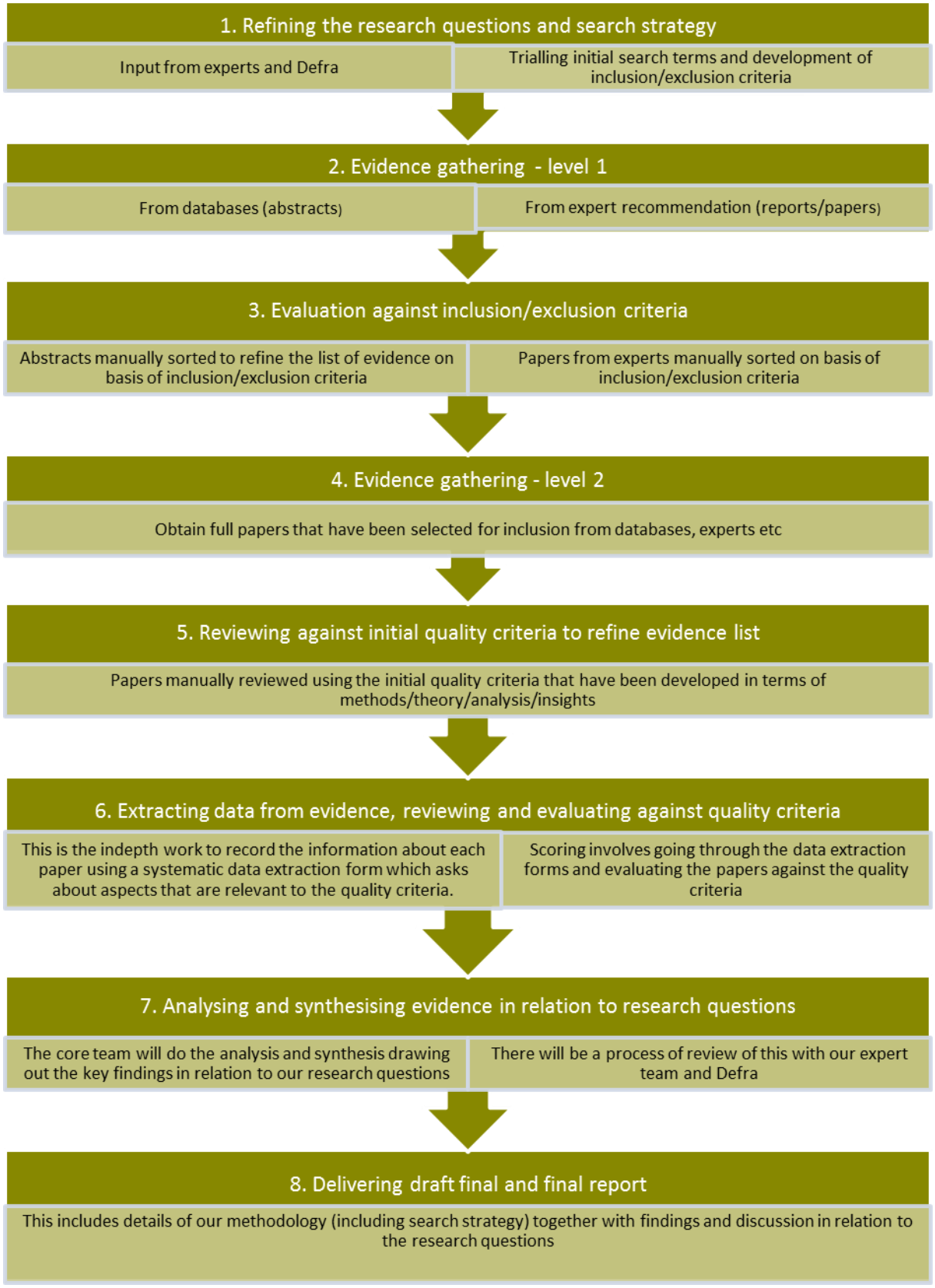


Figure 1: Steps taken in the REA process

Figure 1 shows the steps that were taken in our approach to the REA. A few key points should be noted:

- We asked our experts to give their input on the research questions (Step 1), in relation to the finalised inclusion/exclusion criteria (Step 1) and key sources of literature for the REA (Step 2). A key issue that was agreed was to focus only on floods, but asked our experts about key literature outwith of the flood areas.
- The inclusion/exclusion criteria are those criteria used to decide whether a piece of evidence is included or excluded. The list used is presented in Table 2 with an indication as to whether it was used manually or through the database search terms.

Table 2: Inclusion and exclusion criteria for search strategy

Exclusion/inclusion criteria used for the REA	How implemented in the REA
Exclusion criteria	
Excluded studies concerned with resilience framed solely in an engineering or technical way:	*Done manually as it may not have been possible to tell from the abstracts, plus we wanted some information on property level protection which could come into this.*
Excluded studies reported in languages other than English:	*Done by default given the databases we searched in are all English*
Inclusion criteria	
Included studies published between 1998[5] to current date:	*Done via search terms*
Included only studies about resilience AND flooding:	*Done via search terms*
Included people in the UK who are at risk of flooding (as opposed to just those who have been flooded):	*Done manually as it was difficult to search for this.*
Included studies which aimed to have an impact on resilience in the context of flooding:	*Done manually as this is quite specific*
Included studies that addressed the question of how to measure resilience:	*Done via search terms*
Included studies reporting whether interventions had an impact on resilience in the context of flooding:	*Done via search terms*
Included studies carried out in developed countries:	*Done manually as appropriate. In reality, UK papers were prioritised, especially for the section on interventions, but the non-UK papers were also examined. For the other sections, papers from developing countries were excluded.*

The full search strategy used was the following: flood* AND resilien* AND (communit* OR economic OR cost* OR financ* OR insur* OR behavio* OR vulnerab* OR risk* OR

[5] This date was agreed at the inception meeting because of the 1998 floods after which there was a step change in approaches to flood risk management and research.

mitigate* OR govern* OR institut* OR response* OR household* OR citizen* OR what works) AND pd(1998-2013)) NOT (vegetation OR invertebrate* OR fish OR trout OR salmon OR plant* OR macro* OR micro* OR ecological OR ecosystem* OR crustac* OR biol* OR agro* AND pd(1998-2013). This "NOT" category was added as many references were coming up that were focused on resilience in the natural world. This included the terms "ecosystem" and "ecological" because the majority of papers with those terms were relating to plant and animal ecosystems. As a result, we might have excluded some papers on socio-ecological systems (SES) which could be relevant. However, the references given to us by our experts drew in key works related to flooding within the SES framework which was considered to be a more efficient way of accessing relevant papers than including the term in the full search.

i) The sifting of abstracts was carried out for all the papers that came through from the searches and experts and were allocated against each question.

ii) To limit the scope of the search we used the term "resilience" in every search thereby excluding papers that are not explicitly badged as resilience.

iii) This review is taking place at a specific point in the development of the concept of resilience within flood risk management in the UK and as such provides a useful record of what work is currently using resilience as a framework.

Developing the quality criteria and the data extraction form

The quality criteria and data extraction form were developed for this REA after consulting a number of different approaches (see Interim Research Outline Report for details). There were a number of challenges to that development:

Firstly, the evidence on flood resilience comes from wide range of different theoretical perspectives and different disciplines each with differing criteria for quality making it harder to develop one unified approach.

Secondly, the quality assessment criteria referred to for REAs and Systematic Reviews (REA-toolkit) are framed to a large extent within a quantitative experimental approach to research. Qualitative research is mentioned and approaches are suggested, but the model fits best for research carried out using an experimental design as per e.g. drug trial. Flood resilience research does not fit neatly into these categories.

Taking this into consideration and the need to be efficient we used the Quality Appraisal Tool suggested by the civil service which has 10 questions to ask about the study. http://www.civilservice.gov.uk/wp-content/uploads/2011/09/Qualitative-Appraisal-Tool_tcm6-7385.pdf. This was incorporated into the data extraction form and can be found in Appendix 1.

The data extraction form was devised to provide a record of each of the studies considered relevant for the review and we drew on good practice from other REAs to develop this. In the end we used the forms only on those papers that were reported on in Section 6.

The approach to analysis and synthesis

As discussed in Section 2 it was agreed that the focus of the detailed REA would be on Question 3 as it was most appropriate in terms of type of question for an REA. However, the REA still was to report against the other questions. To do this we took the following approach:

i) For questions 1, 2 and 4 once the papers had been allocated to the questions the analysis started with information from our experts and then drew on papers from the searches. The approach is discussed further in Section 4.

ii) For question 3 all the papers extracted were evaluated using the quality criteria and data extraction forms were completed for those papers. Then those papers were analysed and synthesised. How this worked in practice is reported in Section 4.

4. Summary of Evidence Assessed

Introduction

This section provides the findings from Steps 1-6 in the REA process (Step numbers refer to Fig 1).

Initially, in Step 2, 1,865 references were found and recorded, after being manually sorted on the basis of the abstracts there were 611 references remaining (see Table 3). This first sift was done to remove those papers that were obviously not relevant. Some databases, notably Environmental Science and Pollution and CABI, did deliver the majority of their hits on the natural environment as opposed to 'human' resilience. The location of the publication of the references was also considered, with those covering Africa and the Far East being judged on the quality of the journal and included in cases where the references were considered to be substantive research and omitted if considered to be a commentary piece. This first sift of the papers was done at a very high level by our search expert on the team.

Table 3: A list of the databases searched including the number of references found and the number of references selected using the inclusion/exclusion criteria

Database searched	Numbers found (Step 2)	Numbers selected (Step 3)
Planex	78	40
IBSS	54	39
Worldwide Political Science	17	12
Web of Knowledge	537	128
Scopus	465	53
Aqualine	102	48
PAIS	39	33
AGRIS/CAB	69	30
Sociological Abstracts	34	18
Engineering Village	205	71
Environmental Science and Pollution	205	139
TOTAL	**1,865**	**611**

NB: There are duplicates within this table.

In Step 3 the abstracts of the selected 611 references were then read by our research members of the REA team and 255 were selected based upon the quality and relevance of their abstracts (see Table 4) to the topic area. The 'Number selected through abstracts' does not include absolute figures and includes duplicate references that may have shown

up in multiple databases. The 'Environmental Science and Pollution' database did not include abstracts for all of the references; therefore the assessment was based upon the reference title, journal and key words.

Table 4: A list of the databases searched and the number selected through their abstracts

Database searched	Number selected through abstracts – Step 4 (numbers from Step 3)
Planex	20 (40)
IBSS	13 (39)
Worldwide Political Science	4 (12)
Web of Knowledge	49 (128)
Scopus	32 (53)
Aqualine	13 (48)
PAIS	15 (33)
AGRIS/CAB	16 (30)
Sociological Abstracts	18 (18)
Engineering Village	33 (71)
Environmental Science and Pollution	42 (139)
TOTAL	**255 (611)**

Of the 255 papers a third sift (Step 5) based on the full papers took place where they were assessed by their relevance to each of the project's research questions, those which were not relevant to any of them were excluded at this point, together with those that on reading the full paper did not meet the inclusion/exclusion criteria. The process of matching references to research questions resulted in 82 being selected, with an additional 26 references being suggested by our team of subject experts (see Table 5).

It should be noted that this was an iterative process with the REA team members going through the papers a number of times to ensure that those included were relevant. This process continued through into the analysis phase where sometimes it was as the text was being written that papers became more or less relevant.

Table 5: The number of references selected according to their relevance to the research questions and the number of references suggested from the subject experts

Research Question	Numbers of references from database search	Number of references from experts
Question 1 – Meaning of resilience	11	4
Question 2 – How do we create resilience?	19	5
Question 3 – Evidence of interventions - UK	19	9

Research Question	Numbers of references from database search	Number of references from experts
Question 3 – Evidence of interventions - non-UK	25	5
Question 4 – measuring resilience	18	3
TOTAL	**82**	**26**

Once the papers were allocated to questions then there was final review to see which papers should be taken through into the analysis. This was based largely on relevance to the topic but also the quality of the paper, specifically, if it was in a refereed journal and of relevance it was kept in.

Given the nature of the research questions as discussed earlier it was agreed that the full process of data extraction and quality assessment should be carried out only on the papers reported in Section 6 which focuses on interventions to improve resilience. For the other research questions summary tables were developed showing each of the papers analysed for that section. The summary tables showing the key papers analysed for research questions 1 and 2 are to be found in Appendix 2, for question 3 in Appendix 3 and for question 4 in Appendix 4. An example of a completed data extraction form is in Appendix 5.

The section below provides details on the process of analysis carried out for each section together with quality of the evidence assessed for each section of the report and how what was taken forward for the analysis and synthesis was agreed.

Process and quality of the evidence analysed

Section 5 and Section 7 – Research questions 1, 2 and 4

In these sections the approach taken was more akin to a traditional literature review but backed up with the information found through the database search. For Section 5, we started with references from our experts and from past research using reviews of research as appropriate. The papers on the nature of resilience in relation to flood risk management which came from the database search were situated within a wider discussion around the concept of resilience. This was felt to be important going forward to help Defra consider how resilience might be operationalised at the policy and practice level. Whilst all the papers were read, only those that were strictly relevant to the questions were kept in this Section. For Section 7 most of the papers came from the database search with some from our experts.

Section 6 – Research question 3

In this section we took the REA approach to the point of the data extraction forms and quality assessment and in doing so reduced the number of papers to be written about. As can be seen, 58 papers came through the initial matching to research question 3. This was then reduced to a final 20 papers through an iterative process between three of the research team members and was based on the relevance of the paper specifically we

wanted to focus on UK examples although we have included some non-UK. The key quality criteria was around whether or not the paper reported some primary research around an activity that had been carried out with the clear aim of trying to improve an aspect of resilience to flood risk. This did narrow down the search and as Section 6 shows, there were no papers that rigorously evaluated designed interventions to build resilience. This is a key finding and one that is discussed in Section 8.

Of the 20 papers, two were moved out of Section 6 to be used in Section 5 as they seemed more appropriate. This left 18 papers that form the core of the analysis in Section 6. There are other references within that section but those were not considered core to the review.

In terms of the quality of the papers, the table below gives an overview in relation to the questions asked with the number (out of 18) in each category. Several issues are important to note.

- Only one paper had comparison groups with comparable data, the other paper with comparison groups concluded it was very difficult to compare the case studies in a strict way across variables as they were so context specific.
- In the qualitative papers there was only one that considered the relationship between the researcher and the participants
- None of the papers reported any ethical considerations taken into account – they may have done so but these were not reported.

Table 6: Quality assessment of papers for research question 3

Quality Assessment				
	Yes	No	Not applicable	Not clear in paper
1. Was there a clear statement of the aims of the research? Was it related to the REA questions?	18	0	0	
Methodology				
2. Was the methodology chosen appropriate?	17	0	1	
Research design				
3. Was the research design appropriate to address the aims of the research? Is there a discussion of the choice of research design?	16	0	1	1
Sampling				
4. Was the recruitment strategy appropriate to the aims of the research? If representative sampling was used, was the sampling frame (selection of participants) representative of the population being studied?	11	0	1	6
Data collection				
5. Were the data collected in a way that addressed the research issue? Were the	13	0	1	4

methods chosen clear and were they justified?				
6. If there was a comparison or control group, were they similar enough to the intervention group to be comparable?	1	1	16	0
7. If qualitative research design, has the relationship between researcher and participants been adequately considered?	1	0	5	12
Ethics				
8. Have ethical issues been taken into consideration? Whether consent was obtained from participants and information sheets provided.	0	0	0	18
Data analysis				
9. Was the data analysis sufficiently rigorous? Was it sufficiently described and an appropriate sample analysed? For a quantitative analysis, are enough data presented for results to be valid and useful (i.e. on both the dependent and independent variables).	14	0	0	4
10. Is there a clear statement of findings? Whether the studies gave enough depth and detail to give confidence in their findings. Whether the studies assessed the relevance of their findings to the wider population and/or context.	17	0	0	1

Review of sections

The experts on our project team reviewed the three sections and made suggestions, additions and comments on those sections which have been taken into account in this report.

5. What Does Resilience Mean in the Context of Flood Risk Management?

Introduction

This section focuses on the analysis of evidence around the definition of resilience in the context of flood risk management. For this section the majority of the evidence comes from the project experts and builds on past projects in this area many of which have carried out reviews of relevant literature (e.g. Twigger-Ross *et al.*, 2011; Whittle *et al.*, 2010; ENSURE, 2009a 2009b, 2011; emBRACE, 2012a, 2012b). These papers and reports were taken as the starting point for examining the research questions in this section and were then complemented by the evidence that came through the REA search.

The core documents reviewed for this section are listed in Appendix 2.

Under this overarching question are three sub-questions:

i) What does it mean at an individual, community and society level in relation to flood risk management?

ii) What does resilience look like in practice? Are there examples of resilient communities?

iii) How is resilience created in communities?

In order to answer these questions this section begins with general approaches to resilience in the context of disasters as it is in this wider context, often in relation to climate change, that flood resilience is situated by many authors. This is complemented with more specific evidence from the flooding literature looking at the three sub-questions.

Defining resilience

The term “resilience” has entered into common use within the world of disasters in general over the past two decades with it gaining increased prominence after Hurricane Katrina in 2005 and entering into UK government language around emergencies with the publication of the Civil Contingencies Act (2004) and the setting up of Local Resilience Fora. It came to prominence specifically with respect to flooding after the 2007 flood (Pitt, 2007) followed with work around community resilience by the Cabinet Office (Strategic National Framework on Community Resilience, 2011).

Many authors (e.g. ENSURE, 2009a; Cutter, 2010; Liao, 2012) note the change in concept from an engineering, structural concept of resilience to the more interdisciplinary concept focussed on systems, described as either socio-ecological systems (e.g. Liao, 2012) or socio-technical (Newman *et al.*, 2011). A socio-technical system is one that links a physical system (e.g. flood risk infrastructure) with actors (e.g. flood risk management organisations, communities, individuals), rules (e.g. acceptable flood risk what standards)

and norms (e.g. appropriate action in emergencies) in order to provide a particular function (e.g. flood risk management).[6]

The ENSURE project in their comprehensive review of the concept note that the change in definition from one of "resistance" through to a more proactive approach "adaptation" can be discerned. The move also from a vulnerability focus to a resilience focus within the disaster field can be thought as a paradigm shift to approaching risk (ENSURE, 2009a). Liao (2012: 50) echoes this: "*Overall, resilience theory suggests a paradigm shift in flood hazard management that should focus on building resilience as opposed to maintaining stability*" and indeed this comes through in the review of resilience from the emBRACE project (emBRACE, 2012a). Rather than repeat those reviews we present current definitions, and characteristics of resilience that fit within the framework of a paradigm shift, as this is the direction of travel that can be discerned within the current Defra (2012a: 2) view of community resilience in relation to flooding, "*This project is particularly interested in encouraging "resilience as transformation – owning a need to change" by local individuals and communities in managing flood risk."* Defra (2012a) refer to the Cabinet Office's definition of community resilience which we discuss later in this section.

As we go through this section we will focus on the social aspects of resilience largely because this is the focus of the Pathfinders, but also because this is perhaps a less well developed aspect of resilience:

> *Most of the scientific literature points to resilience within natural systems (e.g., keeping wetlands intact or controlling development), yet the resilience of social and organizational systems is equally significant. Disaster impacts may be reduced through improved social and organizational factors such as increased wealth, the widespread provision of disaster insurance, the improvement of social networks, increased community engagement and participation, and the local understanding of risk (Cutter et al. 2008a), as well as through improvements in resilience within natural systems* (Cutter *et al.*, 2010).

A further key point to make about the work on defining resilience is that the emphasis varies in terms of how empirically grounded the definitions are, and the extent to which those concepts have been rigorously tested in the field. Overall, the definitions provided here have been developed through a combination of conceptual thinking and derived from empirical observations. The types of observations largely (e.g. Bahadur *et al.*, 2010; ENSURE, 2009a; Wardekker *et al.*, 2010) take the form of case studies and qualitative research. Bahadur *et al.* (2010) remark: "*Lastly, the vast majority of the available literature on the resilience concept still tends to be largely conceptual and, while some empirical examples are discussed, there remains a lack of robust case studies that prove or test the theories put forward"* (Bahadur *et al.*, 2010: 19). We would suggest that the current state of play with the development of conceptual frameworks of resilience for disasters in general and flood risk management in particular is that there has been a good deal of clear conceptual work that is drawn from case studies and qualitative work but that those resulting models have not been tested and refined empirically to that point that they might be gain predictive power, remaining largely descriptive.

[6] This definition draws on Geels, F.W.: From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory, Research Policy, 33, 897–920, 2004 and Gersonius, B., Ashley, R and Zevenbergen, C (2012) The identity approach for assessing socio-technical resilience to climate change: example of flood risk management for the Island of Dordrecht. Natural Hazards Earth System Science, 12: 2139–2146.

Following a review of 16 types of resilience (Bahadur *et al.*, 2010), DFID (2011: 6) have a working definition in the context of disasters as "*Disaster Resilience is the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses - such as earthquakes, drought or violent conflict - without compromising their long-term prospects*."

This is elaborated within DFID's resilience framework:

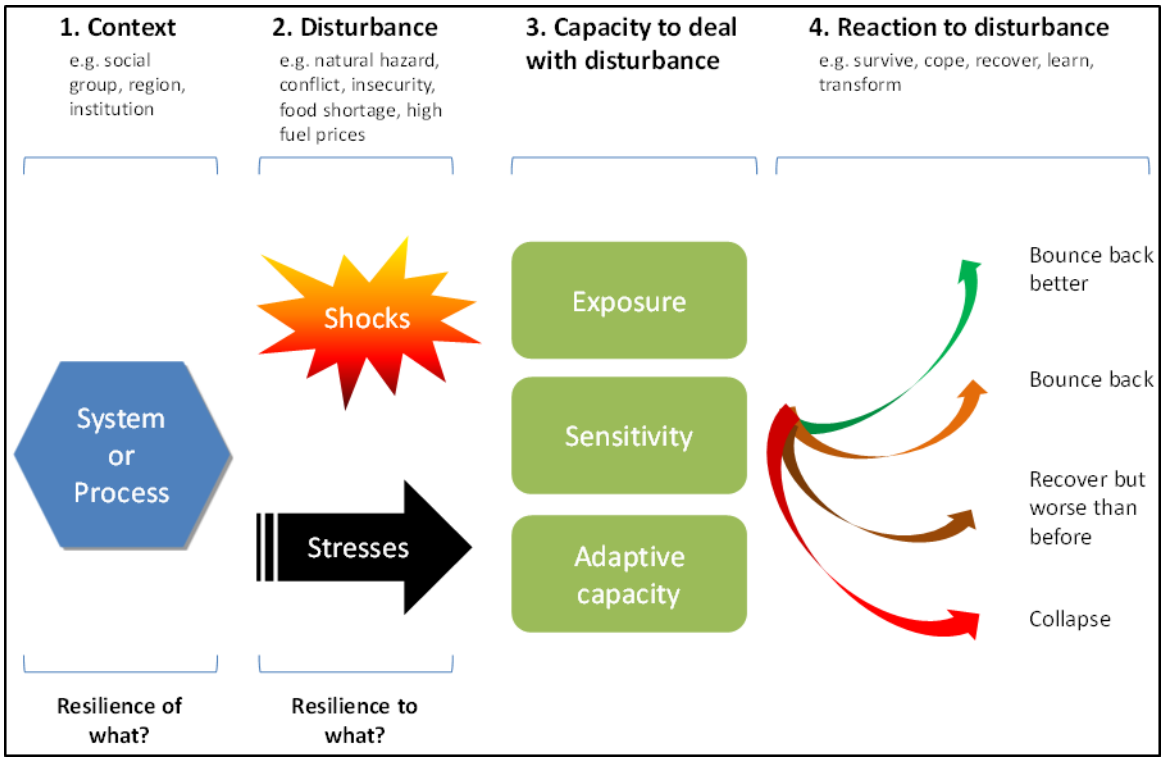


Figure 2: Resilience framework (DFID, 2011)

What is useful here is the framing of resilience as a process and asking the key questions "what is the focus of resilience" and "what is the stress or shock" that it is being resilient to. In our case, the second question is easier to answer than the first since we are focussed on the "shock" of flooding. In terms of what system or process we are focussed on, we would suggest that the Pathfinders are focussed at a number of sub-national levels: some are focussed at the level of geographical communities, and some are targeting specific communities of interest, some are focussed on a smaller number of people in depth and some are focussed on a larger number at broader level. The nature of those systems is something that we return to later in this section, in terms of key resources (e.g. social, economic, etc.) that a system may need to draw upon for resilience and the characteristics of resilient systems (e.g. robustness, adaptability, etc.).

The DFID framework encapsulates the essential features of a number of current definitions of resilience many of which are listed below in the Table from Norris *et al.* (2008).

Table 7: Representative definitions of resilience (Reproduced from Norris *et al.*, 2008)

Citation first author, year	Level of Analysis	Definition
Gordon, 1978	Physical	The ability to store strain energy and deflect elastically under a load without breaking or being deformed

Citation first author, year	Level of Analysis	Definition
Bodin, 2004	Physical	The speed with which a system returns to equilibrium after displacement, irrespective of how many oscillations are required
Holling, 1973	Ecological system	The persistence of relationships within a system; a measure of the ability of systems to absorb changes of state variables, driving variables, and parameters, and still persist
Waller, 2001	Ecological system	Positive adaptation in response to adversity; it is not the absence of vulnerability, not an inherent characteristic, and not static
Klein, 2003	Ecological system	The ability of a system that has undergone stress to recover and return to its original state; more precisely (i) the amount of disturbance a system can absorb and still remain within the same state or domain of attraction and (ii) the degree to which the system is capable of self-organization (see also Carpenter *et al.* 2001)
Longstaff, 2005	Ecological system	The ability by an individual, group, or organization to continue its existence (or remain more or less stable) in the face of some sort of surprise….Resilience is found in systems that are highly adaptable (not locked into specific strategies) and have diverse resources
Resilience Alliance, 2006	Ecological system	The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks—and therefore the same identity. (Retrieved 10/16/2006 from http://www.resalliance.org/564.php)
Adger, 2000	Social	The ability of communities to withstand external shocks to their social infrastructure
Bruneau, 2003	Social	The ability of social units to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize social disruption and mitigate the effects of future earthquakes
Godschalk, 2003	City	A sustainable network of physical systems and human communities, capable of managing extreme events; during disaster, both must be able to survive and function under extreme stress
Brown, 1996	Community	The ability to recover from or adjust easily to misfortune or sustained life stress
Sonn, 1998	Community	The process through which mediating structures (schools, peer groups, family) and activity settings moderate the impact of oppressive systems
Paton, 2000	Community	The capability to bounce back and to use physical and economic resources effectively to aid recovery following exposure to hazards
Ganor, 2003	Community	The ability of individuals and communities to deal with a state of continuous, long term stress; the ability to find unknown inner strengths and resources in order to cope effectively; the measure of adaptation and flexibility
Ahmed, 2004	Community	The development of material, physical, socio-political, socio-cultural, and psychological resources that promote safety of residents and buffer adversity

Citation first author, year	Level of Analysis	Definition
Kimhi, 2004	Community	Individuals' sense of the ability of their own community to deal successfully with the ongoing political violence
Coles, 2004	Community	A community's capacities, skills, and knowledge that allow it to participate fully in recovery from disasters
Pfefferbaum, 2005	Community	The ability of community members to take meaningful, deliberate, collective action to remedy the impact of a problem, including the ability to interpret the environment, intervene, and move on
Masten, 1990	Individual	The process of, capacity for, or outcome of successful adaptation despite challenging or threatening circumstances
Egeland, 1993	Individual	The capacity for successful adaptation, positive functioning, or competence…despite high-risk status, chronic stress, or following prolonged or severe trauma
Butler, 2007	Individual	Good adaptation under extenuating circumstances; a recovery trajectory that returns to baseline functioning following a challenge

NB: Because of the focus, definitions of community resilience are presented here in disproportionate frequency. Definitions describing larger (ecological) and smaller (individual) levels of analysis were representative of others in the literature.

More recent definitions add further detail to the definition with ENSURE (2009a) quoting the UN/ISDR definition of resilience, highlighting the issue of time within this definition: "*The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in* ***a timely and efficient*** *manner, including through the preservation and restoration of its essential basic structures and functions* (ENSURE, 2009a: 30).

Within the UK, the National Strategic Framework for Community Resilience, takes the following definition of resilience: "*The capacity of an individual, community or system to adapt in order to sustain an acceptable level of function, structure, and identity*" (Cabinet Office, 2011: 10). This definition focuses on adaptation but also adds in the notion of identity that which makes a community or individual unique. Certainly, for consideration of resilience at the individual level, identity becomes a key aspect as will be discussed later in this section.

In the context of climate change, Wardekker *et al.* (2010: 988) propose an operational definition of a resilient system:

> *A system that can tolerate disturbances (events and trends) through characteristics or measures that limit their impacts, by reducing or counteracting the damage and disruption and allow the system to respond, recover and adapt quickly to such disturbances.*

This definition takes it a step further by operationalizing the concept and taken together with a set of characteristics which using workshops and interviews were turned into practical actions at the level of the city (Wardekker *et al.*, 2010). This definition perhaps more than others highlights the role of minimising negative impacts.

In the context of flooding, Twigger-Ross *et al.* (2012) drawing on Whittle *et al.* (2010) and others (Pelling, 2010; Watson *et al.*, 2009; Medd and Marvin, 2005) present an articulation of the "reaction to risk" part of the DFID model and this is presented in Box 2. In terms of data Whittle *et al.*'s work focussed on the recovery from flooding in Hull, UK 2007 and, taking a diary based approach is one of the few studies examining longer term recovery from flooding in this case up to 18 months. Watson *et al.*'s (2009) case study revisited Carlisle since it had flooded in 2004 examining the ways in which resilience had been built in different ways and at different scales using focus groups and interviews. Twigger-Ross *et al.* (2012) carried out four case studies of different types of emergency (two of which were floods) and examined the types of resilience from those cases and these are discussed later in this section.

Box 2

Types of resilience

Resilience as resistance – holding the line, preparing for the last disaster. This is useful when it prepares people for a hazard: e.g. flood gates on houses but not so useful when the hazard is not as anticipated: e.g. overtopping of flood defences that overwhelms flood gates and no plan for evacuation.

Resilience as bounce-back – getting back to normal…. pretending it hasn't happened. Useful in terms of an optimistic rhetoric. Not so useful because it can be unrealistic and can lead to reproduction of vulnerabilities.

Resilience as adaptation – adjusting to a new normal…. accepting that your world has changed which should ensure that vulnerabilities are not reproduced. Can be hard for people to accept living with hazards.

Resilience as transformation – owning the need to change.. transforming to meet future threats Radical change (physical, social, psychological, economic) in the face of current or future hazards owned by individuals and communities (of all types).

The first two types of resilience highlighted above fit into Dovers and Handmer's (1992) definition of "reactive resilience" where the approach to the future is to maintain the status quo and the quest is for constancy and stability. The latter two fit more into the concept of "proactive resilience" (Dovers and Handmer, 1992) which is where the inevitability of change is accepted and a system is created that is capable of adapting to new conditions.

Finally, Cutter *et al.*'s (2008) DROP model helps to further unpack the "system" part of the DFID model (see Figure 3 below) as it usefully distinguishes between inherent resilience and vulnerability (see the triangle) and emergent or adaptive resilience. The former is that which is there as part of the existing place or system and the latter is that which may emerge in relation to hazard or disaster impact.

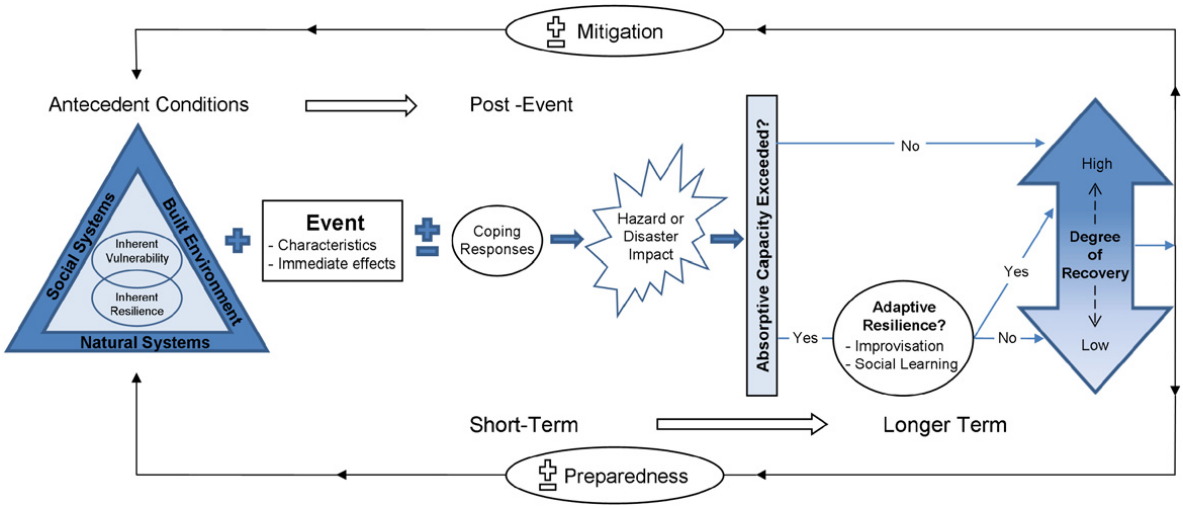


Figure 3: Cutter *et al.* (2008) disaster resilience of place (DROP) model

Neal *et al.* (2011) discuss the concept of emergency in relation to the flood in Hull in 2007 showing how groups, networks, and activities emerge during and after the flood "Emergence has been described as behaviour that is not explicitly apparent from the parts of the system and when it then arises, is therefore unexpected, unplanned and inevitable in any complex system. An essential element of emergence is that it arises from interaction between agents. Unplanned action by one particular individual would not constitute an emergent behaviour, nor would activity by groups that was pre-planned or centrally directed. Emergence is evident when individuals or groups work together in unplanned or unanticipated ways, or new networks are formed in response to an event that would not have existed otherwise" (Neal *et al.*, 2011: 264). As is discussed in the next section having a system that is adaptable and enables emergent behaviours is important to resilience.

These definitions are very helpful to frame work on resilience. The next two sections provide more detail on the characteristics of resilient systems i.e. the types of properties that are thought necessary in order for systems to be resilient. After that we discuss the types of resources or capacities that have been discussed as contributing to resilient systems (e.g. economic, social etc). This elaborates on the "capacity to deal with disturbance" components of the DFID model.

Characteristics/dimensions of resilient systems

5.22. Following an extensive review of definitions of resilience together with case study analysis of the Summer Floods 2007 (UK); Hurricane Katrina (US), Kobe (Japan) and Kocaeli (Turkey) earthquakes , the ENSURE (2009a) project extracted a set of characteristics or dimensions of resilient systems (see Table 7). These were then further developed into a model of resilience which is presented as Figure 4.

Table 7: Findings from analysis of resilience dimensions (ENSURE, 2009a: 42)

AUTHOR	YEAR	DIMENSIONS/PROPERTIES/CHARACTERISTIS/ATTRIBUTES	TARGET
Folke et al. (Resilience Alliance)	2002	Diversity Redundancy Adaptability Self-organization Innovation Memory Experience & knowldge Learning capacity Transformability	Complex Adaptive Systems
Fiksel	2003	Diversity Adaptability Cohesion Efficiency	Systems
Godshalk	2003	Diversity Redundancy Strenghts (Resistance) Adaptability/Flexibility Collaboration Interdependence Autonomy Efficiency	Cities
Bruneau et. al **Chang et al.** **Davis** **Tierney & Bruneau**	2003 2004 2005 2007	Redundancy Robustness Resourcefulness Rapidity	Communities
Walker et al.	2004	Resistance Latitude Precariousness Panarchy	Socio-ecological systems
Adger et al.	2005	Diversity Redundancy Spatial pattern	Ecosystems
Van der Veen et al.	2005	Redundancy (including substituability and transferability)	Economic systems
Chuvarajan	2006	Diversity Redundancy Self-organization Memory Networks Innovation Individual capacity Spatial scale interaction Temporal scale interactions Self-reliance Feedback	Municipal communities
Maguire and Hagan	2007	Resistance Recovery Creativity	Social systems
UNESCAP	2008	Redundancy Robustness Resourcefulness	Socio-ecological & economic systems
Briguglio et al.	2008	Efficiency Rapidity Flexibility	Economic systems
McDaniels et al.	2008	Robustness Rapidity	Infrastructure systems

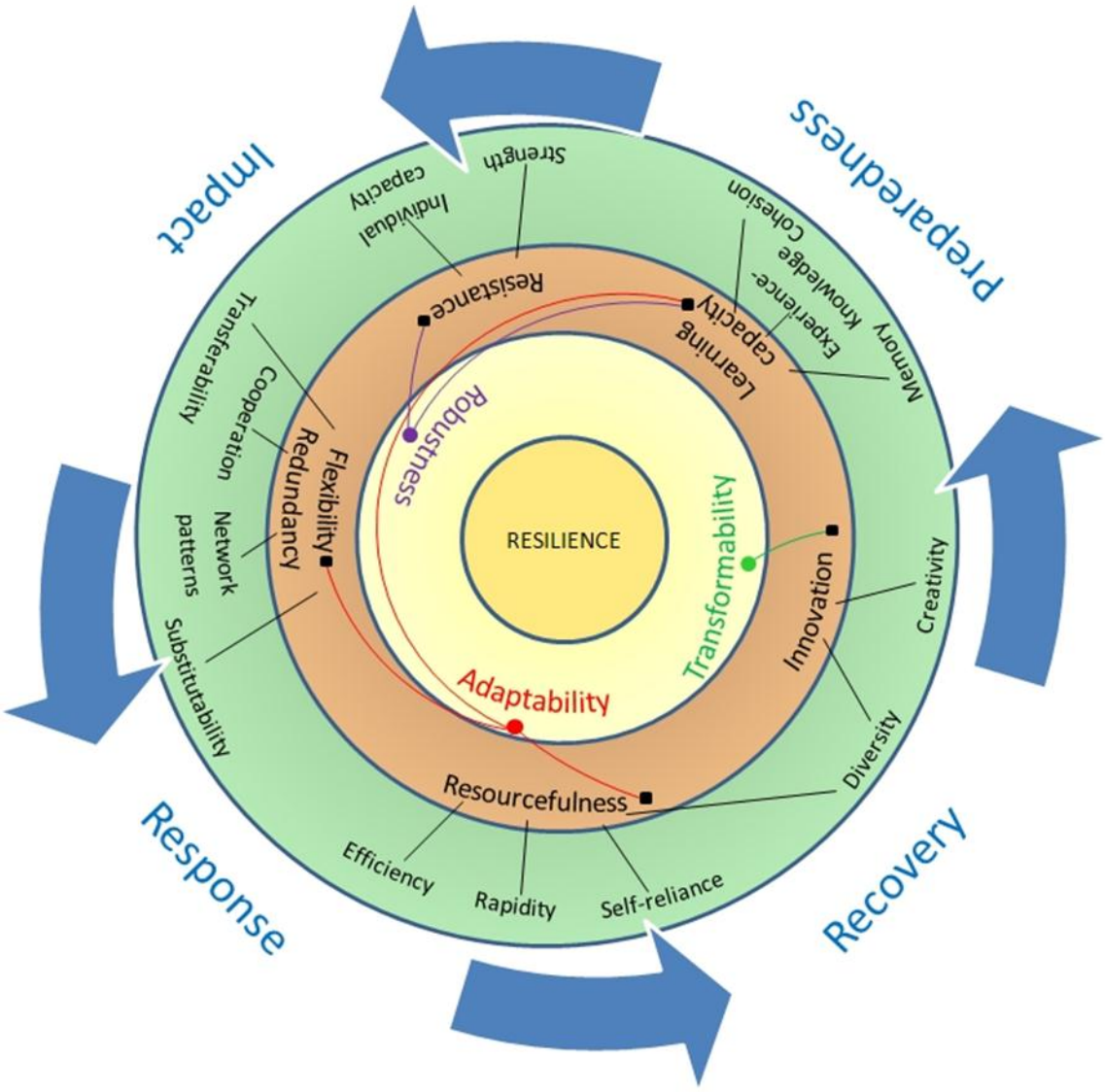
Source: ENSURE (2009a)

These characteristics can seem quite abstract, and do need grounding in specific examples, and operationalizing with respect to flood risk. Wardekker *et al.* (2010) do this to an extent in relation to flood risk and we report on this within the section on "resilience at the society level" later on in this section. They have a list of six dimensions, drawing on key papers from within the socio-ecological systems framework (e.g. Folke, 2006; Adger, 2000; Carpenter *et al.*, 2001; Walker *et al.*, 2004). These characteristics are:

- Homeostasis: multiple feedback loops counteract disturbances and stabilise the system.
- Omnivory: vulnerability is reduced by diversification of resources and means.
- High Flux: a fast rate of movement of resources through the system ensures fast mobilisation of these resources to cope with perturbations.
- Flatness: the hierarchical levels relative to the base should not be top-heavy. Overly hierarchical systems with no local formal competence to act are too inflexible and too slow to cope with surprises and to rapidly implement non-standard highly local responses.
- Buffering: essential capacities are over-dimensioned such that critical thresholds in capacities are less likely to be crossed.
- Redundancy: overlapping functions; if one fails, others can take over.

Three of these dimensions are not captured by the ENSURE model: homeostasis, flatness and buffering (although within this is the idea of resistance). This is perhaps because the Wardekker *et al.* (2010) framework was developed in context with a specific case study in mind whereas many other papers focus on the conceptual and theoretical. These dimensions, specifically flatness, bring into play the concept of governance which we will return to in a later section.

Figure 4: Key dimensions of resilience in the disaster cycle



From this it can be seen that the core dimensions of resilience (at the centre of the diagram) are:

- Robustness: the maintenance of desired characteristics of the system in spite of changes to the system;
- Adaptability: the capacity of actors in the system to influence resilience (Walker et al., 2004) or similarly the capacity of actors in a system to manage resilience in the face of uncertainty and surprise (Gunderson and Holling, 2001). It is related to learning and flexibility to change;
- Transformability: the capacity of people to create a fundamentally new social-ecological system when existing conditions (ecological, social, political or economic).

These dimensions at the centre of the diagram are suggested as the main goals to achieve in relation to different phases of the disaster cycle. In the second circle these are the dimensions that need to be preserved and strengthened in order to enhance resilience whilst the concepts in the third circle are considered to be those that are linked to concepts in the second circle and are amenable to policy change in order to enhance resilience.

What is interesting about the ENSURE model is the suggestion that the three different aspects of resilience may be of more relevance at different points in the disaster cycle. As the diagram shows, robustness of the system which is dependent on resistance is something that will be important at the impact stage. With respect to flooding for example, having flood gates will improve the robustness of a home, hopefully preventing water from coming into the structure. On a larger scale flood defences also have this function. Adaptability is likely to be important in the response phase where the system is able, because of flexibility, redundancy and resourcefulness, to adapt and change in the face of uncertainty and fast moving events. Finally, transformability becomes more salient during the recovery phase and thinking longer term, that is, are there ways of behaving and relating to each other that need to be completely changed or longer term structural aspects that if change could help mitigate the flood via spatial planning?.

This is a very useful way of conceptualising resilience as it starts to provide a view of what a resilient community/institution might look like. It also enables resilience building to be carried out in a number of different ways at different levels and within different domains/capacities. By this we mean that for example: a local authority might invest money in building the robustness of their infrastructure to damage from flooding (e.g. flood defences, roads, etc.) but as well will be developing their staff and organisational structures to be able to manage uncertainty (e.g. by having exercises that work through worst case scenarios, mapping out how structures work before during and after a flood and also to develop a learning culture so that lessons from each incident are examined and acted upon).

The aspects drawn out by Whittle *et al.* (2010) are threaded through these core aspects of resilience and Norris *et al.* (2008) also propose three dynamic attributes, which networked capacities (discussed further below) require if they are to be effective in producing community resilience. These attributes are:

1) Robustness: the capacity must be resistant to a wide variety of dangers.
2) Redundancy: elements must be substitutable in the event of disruption or degradation, (e.g. social networks need numerous interconnections in order that communication is not stalled by the removal of a single network member).
3) Rapidity: how quickly any needed resources can be accessed and used.

In addition, this way of discussing resilience ensures that it is made sense of as a dynamic process, to be considered "…in terms of relationships and processes rather than as a static characteristic of an individual, household, public service or community. In other words, resilience is not so much a response to the flood hazard itself, but is an emergent characteristic of the way in which the flood response and the subsequent recovery process are managed" (Whittle *et al.*, 2010:12).

Capacities/resources for building resilience

A further key approach to resilience that cuts across the "dimensions" approach discussed above is what might be called the "capacities" or "resources" for resilience. This refers to those capacities across a number of domains that exist within a system before an emergency and will be drawn upon during an emergency. They provide the foundation for resilience within the disaster/emergency situation. These resources are perhaps what might be termed the "what" of resilience that is what is needed to develop resilience. Response is built using pre-existing community capacities, which are expanded or extended in line with a – perhaps dramatically – identified need (Dynes, 2005). For

example, Norris *et al.* (2008) describe community resilience as process linking a network of adaptive capacities. These capacities are:

- Economic development: e.g. a community's resilience depends not only on the volume of economic resources available to it, but also on their diversity. The capacity to distribute post-disaster resources to those who most need them is also vital.
- Social capital: e.g. social networks need structure, institutions of support provision, rootedness, a commitment to networks goals and grass-roots leadership. To this we would add that trust and reciprocity are also vital factors in the development of social capital and that these are developed with the benefit of actual, long-term (good or bad) experiences in people's lives or in their local environment (McCulloch, 2003).
- Information and communication: e.g. the need for systems and infrastructure for information exchange and a shared meaning and purpose which means that communications will be understood in the intended context.
- Community competence: e.g. a capacity for action and decision-making to be achieved collectively and for the proactive development of efficacy and empowerment.

Cutter *et al.* (2010: 6) take a pragmatic approach to the definition of resilience in their paper focussed on the development of indicators to measure disaster resilience. They start from the point that "*there is a consensus within the research community that resilience is a multifaceted concept, which includes social, economic, institutional, infrastructural, ecological, and community elements* (Bruneau *et al.*, 2003; Cutter *et al.*, 2008a, b; Gunderson, 2009; NRC, 2010; Norris *et al.*, 2008)." They develop their indicators around these five aspects but with a focus at the level of community, which in turn draws upon Norris *et al.*'s 2008 (and others') approaches to resilience:

i) Social resilience: this broadly covers demographic variables (e.g. age, number of people in household, disability etc.). Some of these are characteristics which have been shown to increase vulnerability to flooding and so it is important to measure those specifically (e.g. disability). It also includes connectivity in terms of internet and mobile phones.

ii) Economic resilience: This category focusses on those variables which give an indication of economic resilience (e.g. employment status, home ownership, insurance cover and levels of deprivation). Evidence shows that having greater economic resources can increase resilience to flooding.

iii) Institutional resilience: The category is focussed on what institutional arrangements and experience there is within the community relating to flooding. This means individual engagement with local institutional arrangements for flood resilience, views on governance of flood resilience and flood experience e.g. membership of flood action groups, signed up to Flood Warning Direct (FWD), responsibility for flood protection, experience of flooding, etc.

iv) Infrastructure resilience: This category focuses on type of housing together with any actions people might have taken to increase their household's resilience to flooding.

v) Community capital: This category focuses on the existing networks and relationships within the local area (e.g. knowing neighbours, informal help

given/received, number of community groups belonged to, etc.). Evidence suggests this is the “glue” that keeps communities together and provides the foundations upon which community flood resilience can be built.

The relationship between resilience and vulnerability

Before we go on to examine resilience at different levels it is important to say something about vulnerability and its relationship with resilience. There is quite an extensive literature on social vulnerability in relation to climate change (e.g. Twigger-Ross and Orr, 2012), disasters (e.g. Cutter *et al.*, 2008) and natural hazards (e.g. Tapsell *et al.*, 2010). This review does not intend to review that work comprehensively but rather to provide a summary of the key issues and more importantly its relationship with resilience in general and its role in flood risk more specifically.

Interestingly, social vulnerability was a key term discussed in relation to social issues and flooding in the UK until fairly recently (e.g. 2012) when the rhetoric has moved towards resilience, and using resilience in a context to mean more than structural resilience. As a concept it is related to resilience with some authors suggesting it is the opposite of resilience with others taking a more nuanced view that a person/community can be vulnerable y*et al.*so be resilient because s/he has capacities to adapt or overcome that vulnerability: “*The main output of long discussions, readings and reflection is that resilience cannot be simply considered as the —flip-side of vulnerability. In other terms, a resilient community is not just a community manifesting low levels of vulnerability*” (ENSURE, 2011: 12).

Work on social vulnerability and flooding has been carried out over a number of years now in the UK and so findings on what makes people more vulnerable to flooding at the individual level are becoming quite well established. Conversely what makes people resilient to flooding is less well established. In discussing vulnerability it is important to be clear about how it relates to resilience and how we are using it within this review. Cutter *et al.* (2008) provide a very useful review of the different ways in which vulnerability and resilience have been conceptualised. We are not going to rehearse those discussions here but rather to say that we take Cutter *et al.*’s (2008: 602) view:

> *Contrary to some conceptualizations where resilience and vulnerability are oppositional, we propose that there is overlap within these concepts [vulnerability and resilience] so that they are* ***not totally mutually exclusive, nor totally mutually inclusive****. There are many characteristics that influence only the vulnerability or only the resilience of a community. On the other hand, there are social characteristics that influence both vulnerability and resilience (socio-economic status, education, and insurance, for example).*

Further we would suggest that vulnerability is a function of the exposure and sensitivity of a system, and that:

> *Vulnerability is the pre-event, inherent characteristics or qualities of social systems that create the potential for harm….Resilience is the ability of a social system to respond and recover from disasters and includes those inherent conditions that allow the system to absorb impacts and cope with an event, as well as post-event, adaptive processes that facilitate the ability of the social system to re-organize, change, and learn in response to a threat* (Cutter *et al.*, 2008: 599).

What is important here is that research shows that there are certain characteristics that make those who have those characteristics more likely to suffer negative impacts of flooding. We call those vulnerability characteristics and they are discussed in relation resilience at the individual level in the section below.

A further key issue for resilience is ensuring that pre-existing vulnerabilities (or inherent vulnerability after Cutter *et al.*, 2008) are not reproduced through the recovery process. One key issue with resilience as "getting back to normal" is the danger that "normal" will mean the continuation of vulnerabilities which will mean that impacts will be felt just as heavily the next time it floods. For example, Whittle *et al.* (2010) report on how after the Hull flood 2007 insurance companies were not willing to put in measures to mitigate flooding into homes that had been flooded which would have been an adaptive response, but rather put the homes back exactly as they had been before the flood thereby reproducing any existing structural vulnerabilities. This would mean that the damage from another flood would be repeated.

Taking a vulnerability or resilience focus has oriented research to different but inextricably related relevant aspects to disaster management:

> *What seems to emerge in literature is a different focus of vulnerability and resilience studies: the first are more oriented towards the identification of weaknesses, fragilities that make a given territory, a given community, a given country unable to resist the stress provoked by an —external source. Looking at resilience we appreciate the capacities to react, to overcome the problems created by the same existence of vulnerabilities and to —bounce back despite damages and disruption to ordinary life* (ENSURE, 2011: 12).

What emerges strongly within the vulnerability literature is the issue of inequalities and how they are played out in the context of disasters and emergencies. This leads into the area of environmental justice and an understanding of the more systemic societal issues. Walker and Burningham (2011) consider those social vulnerabilities that reflect and reproduce the existing pattern of inequalities in society, or systemic inequalities. So the people who are most vulnerable to flood impacts in many cases will be those people who are most vulnerable to other negative impacts (i.e. people who are already affected by poverty, poor health, disabilities which leads to a consideration of fundamental issues of inequality and social justice). Cutter, Boruff, and Shirley (2003) extend this to place related inequalities as well:

> *Social vulnerability is partially the product of social inequalities – those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond. However, it also includes place inequalities – those characteristics of communities and the built environment, such as the level of urbanisation, growth rates and economic vitality that contribute to the social vulnerability of places*.

This is an area of vulnerability research that needs to be pulled through more clearly into the area of resilience for resilience building to be effective and why resilience as "bounce back" is not enough for longer term flood risk management. As ENSURE (2011: 13) suggest: "Sometimes getting back to the exact pre-event conditions is just the opposite of resilience, particularly when high level of vulnerabilities characterized that condition."

The issue of underlying vulnerabilities and inequalities in terms of race, gender and poverty were starkly revealed by Hurricane Katrina. Weber and Messias (2012) provide an

analysis of the gap between the “hoped for” recovery and the reality of recovery and this is summarised in Box 3 below. What comes through are the more systemic issues of unequal power relations.

Box 3

Case example: Hurricane Katrina

In their research with front-line recovery workers along the Mississippi Gulf Coast following Hurricane Katrina, Weber and Messias (2012) discuss key barriers to recovery as seen through the eyes of community-based, non-governmental organisations in the middle ground between the disadvantaged communities they were advocating on behalf of and the powerful alliances that controlled access to resources. The researchers carried out field observations, document analysis, and interviews with 32 front-line workers from 27 different non-governmental organisations, and adopted a feminist intersectional framework in an inquiry into the practice of power at individual, community and societal level and systems of inequality (such as race, gender and class).

Immediately after the Hurricane and floods had subsided, respondents reported having felt optimistic that the reconstruction and recovery programmes would create more socially just communities, “that things would be put back together again better” (2012:1836). However, they soon realised that despite the rhetoric, ‘better’ did not mean better for the disadvantaged communities they were advocating on behalf of; their interviews describe how financial and other recovery resources were directed towards business and corporate interests as few support mechanisms remained available for the vulnerable communities they served.

Additionally, *“women talked of marginalization and exclusion from decision making on the basis of gender and race, of routinely being denied a voice, and of being disrespected as they confronted more powerful, usually white male, actors. Working for social change against entrenched power structures added a gendered layer of emotional, psychological, and physical struggle to front-line recovery work”* (2012:1838). Those advocating on behalf of immigrants faced an additional layer of stress and isolation amidst rising anti-immigrant rhetoric across the country. This research clearly highlights the ways in which the unequal exercise of power at the micro and macro levels impacts on building community resilience.

These issues of power relations, politics are not prominent within some definitions of resilience. Cannon and Muller-Mahn (2010) usefully provide a critique of the move towards a resilience framing away from vulnerability. They suggest that as it has emerged from a predominantly natural science system. The focus shifts away from a perspective that has systemic issues at its heart to one that lacks a level of political analysis and acknowledgement of agency of key actors. In addition, it suggests that a resilience framing may reduce the influence of social science analyses of disasters and development. This is an important issue and in this report we take the view that both resilience and vulnerability need to be understood in order to be able to develop successful adaptations / transformations to flood risk. To underplay or ignore social inequalities and power relations between actors within the flood risk system would be to provide an incomplete analysis of the issues and subsequently of any solutions developed to address those issues.

What does resilience mean at an individual, community and society level in relation to flood risk management?

Much of the work discussed above conceptualizes resilience a general way, consisting of core principles/dimensions together with domains of resource. Whilst some of the work is clearly grounded in specific systems, such as cities (Wardekker *et al.*, 2012; Liao, 2013) and communities (Norris *et al.*, 2008; Cutter *et al.*, 2010), it remains fairly abstract and, again with exceptions, not specifically focused on flood risk. This is mainly because the literature on flood risk management has only started to use the term "resilience" beyond its meaning in engineering, within the fairly recent past. Previously to this there was much more emphasis on understanding vulnerability (for overviews see: Tapsell *et al.*, 2010; Twigger-Ross and Orr, 2012). As noted above, the literature comes from disaster and climate change work. This means that there is limited evidence around the different levels of analysis in relation to flood risk management: individual, community and society. However, in the following sections we draw out what evidence has been found from the database searches and from our expert input.

It is useful at this point to reiterate that when we are considering "flood risk management" we refer to the whole cycle including planning through to recovery and not just the incident management or emergency phase.

The social impacts of flooding in the UK

To begin with it is useful just to highlight the research on the social impacts of flooding in the UK since this is what we are aiming to develop resilience to.

Research has examined both health and social impacts seeking to describe and in places quantify the impacts on people's lives of flooding (e.g. Hajat *et al.*, 2005; HPA, 2011; RPA/FHRC, 2004; Werrity *et al.*, 2007; Walker *et al.*, 2006). Below is a summary of the range of impacts that have been considered in research:

- Economic impacts, including damages to the property and its contents.
- Non-economic losses, including the loss of personal or sentimental items. The most important losses for victims are often personal possessions such as photographs.
- Impacts on physical health and psychological health.
- Impacts associated with evacuation and temporary accommodation.
- Household disruption, which may include: the stress and inconvenience of living away from the home if evacuation is necessary, cleaning and repairing, and dealing with builders and insurers.
- Community and neighbourhood changes, e.g. changes in population due to evacuation which may be short or long term.

Research into the impacts of flooding from climate change (Defra, 2012b) for the Climate Change Risk Assessment, presented the mental health impacts as a major impact that arises from flooding. The Health Protection Agency (2011) reviewed the mental health effects of flooding and concluded:

> *The effects of flooding and disasters on people's health, relationships and welfare can be extensive and significant. Flooding can have profound effects on people's welfare, employment, mobility, wellbeing, psychosocial resilience, relationships and mental health. It can pose huge social and welfare problems that may continue over extended periods of time because of not only being flooded (the primary stressor), but also because of the continuing secondary stressors that arise as people try to recover their lives, property and relationships.*

This conclusion summarises the evidence around the mental health effects of flooding.

In terms of what causes the anxiety and stress as Tunstall *et al.* (2006: 379) suggest "There is some evidence in the study that the way the aftermath of flooding is handled by community and professional agencies, for example, those responsible for flood warning, evacuation and guidance on water contamination can have a significant impact on mental health outcomes." This was a key finding from the 2007 floods as reported by Whittle *et al.* (2010), that the stress of dealing with builders, insurance etc. was greater than the stress from the flood itself.

What is useful to note is that although people may well be distressed, this does not mean that they are not necessarily behaving in resilient ways. What becomes an issue is when those mental health issues shift into the area of disorders that are debilitating and mitigate against recovery and resilience.

> *Thus, recovery from distress after disasters including flooding is characterised by adaptation to circumstances that have changed and rebuilding rather than hoping that the situation will return exactly to that which existed before the flooding occurred. Masten, (2001) for example, points out that resilience is a process that reflects natural human adaptation. People may, then, experience distress as a consequence of the enormity of the events that have affected them and as they adapt to and deal with the impact of those events. The authors of this report observe that people being distressed for a period of time (in the case of flooding that time may be drawn out) is not pathological in itself, and that they may experience intense feelings while also behaving in resilient ways* (Health Protection Agency, 2011: 72).

Whilst there has been much work on these mental health effects, as well as the social impacts of flooding less has been considered in terms of how to build resilience to these mental health impacts. Mainly, the focus has been on trying to encourage changes in behaviour towards more resilient actions. For the Environment Agency resilient actions at the level of the individual for before, during and after a flood (see www.environment-agency.gov.uk/homeandleisure/floods/default.aspx) include practical actions around knowing your flood risk, making a flood plan, having a flood kit, being aware of vulnerable neighbours and friends, putting valuables upstairs, and acting safely after the flood has happened. In Section 6 we discuss how interventions aimed at behaviour change have been successful or not.

Resilience at the individual level in relation to flood risk management

At an individual level when considering resilience in relation to flood risk management a number of key issues emerge from the literature which we highlight below. This is not intended to be exhaustive, but rather to raise some of the specific individual level aspects of resilience that have been found to be important in the context of flood risk management.

As noted above, vulnerability is inextricably linked to resilience, and work on understanding vulnerability characteristics in relation to flooding in the UK provides useful insights.

Vulnerability characteristics

As discussed above, the area of vulnerability characteristics is one where there have been a substantial amount of research in relation to flooding but it has tended in the UK to focus on the individual level of analysis. The table below provides an overview of the key social vulnerability characteristics that have been shown to negatively exacerbate the social impacts of flooding.

Table 8: Social Vulnerability Characteristics

Social vulnerability characteristics	
Poor mental and physical health	Prior poor health exacerbates the physical and psychological impacts of flooding. Age is not linked in a linear fashion to increased health effects of flooding but e.g. over 75s used as a measure because of the sharp increase in conditions sensitive to damp over that age (Tapsell *et al.*, 2002). Houston *et al.* (2011: 41) in their work on pluvial flooding in urban areas provide two relevant conclusions about the relationship between poor health and projections of daily rainfall: *"Social deprivation and poor health are more prevalent in urban areas with the highest wettest day intensity.*
Fewer financial resources, financial deprivation and lack of access to systems and support services (e.g. health care)	Having financial resources has been found to be a buffer against severity of a flood event. Low income households are less likely to have insurance (ABI, 2007) and the stress of flood has been shown to be felt more severely by low income households (Werrity *et al.*, 2007). People on low incomes are more likely to live in houses more at risk from floods and storms. Low income interacts with other vulnerabilities i.e. poor health/lack of access to systems/support services. That is, people on low incomes are more likely than those on higher incomes to have poor health and lack of access to systems and support.
Lack of social networks	People without any social networks are unlikely to receive information or support during a flood. Those with networks more likely to receive help possibly because of networks rather than need alone (Tunstall, 2007)
Gender	Research suggests that women are often more severely affected than men by floods. Walker and Burningham (2011), provide a useful overview of evidence in this area highlighting that women tend to experience particular physical and psychological flood-related health problems themselves as well as tending to carry the physical and emotional burden of caring for sick household members

Social vulnerability characteristics	
Social Class	Social class[7] has been found to be a predictor of awareness of your home being in an area that may be at risk of flooding, with those in social classes A and B showed greater awareness of their flood risk than those in social classes D and (Burningham, Fielding and Thrush, 2008). This could be explained by lower levels of education or participation.

It is useful to highlight those characteristics that are likely to exacerbate negative social impacts of flooding, and it is important to recognise the interactions between these characteristics. Steinführer *et al.* (2009a) conclude:

> *Two main findings need to be highlighted: Firstly, no single social variable or set of social variables could be identified to explain all aspects of vulnerability, coping and resilience of local communities and social groups. Different social factors come into play in the different phases of a flood event and, more particularly, affect specific behavioural responses and coping activities. Neither was there one single social group (the very old, the very poor, those without a social network etc.) who proved to be particularly vulnerable throughout all of the phases. Moreover, in many cases the relation between vulnerability and the underlying social structures did not turn out to be linear. Secondly, context is key: both local conditions and event specifics need to be taken into account to explain social vulnerability to flooding – it is thus always rooted in specific spatial, socio-economic, demographic and cultural contexts.*

The role of identity in personal flood risk management decisions

Harries (2008) provides some useful thinking on the role of identity within resilience. Building on Giddens' concept of "ontological security" he suggests that the reason some people refuse to carry out risk reducing measures such as property level protection is because it could threaten this sense of security "*According to Giddens, an ontologically secure person is someone who is free from existential doubts and who is able to believe that life will continue in much the same way as it always has, without threat to the familiar representations of time, space and identity*" (Harries, 2008: 482). The way we represent different concepts to ourselves (e.g. home, nature, society) is done in a way so as to preserve that sense of security. In his qualitative analysis of interview data, he shows how putting flood protection on the front of a house may be a sign that the house is not safe and secure, something that is important to ontological security. Sims *et al.*, (2009) in the context of understanding the impact of flooding on carers also reflect on the nature of home as a secure space, and the threat of making that secure place unsafe that a flood might bring. "*Emotional attachments to the home are of course revealed when disruption occurs. The meanings of home can be transformed from the inside by life events such as birth, marriage, illness, or bereavement (Angus et al., 2005; Hockey, Penhale, & Sibley, 2001; Morris & Thomas, 2005) and equally from external events such as burglary, toxic pollution, earthquakes, and risks from industrial processes. The latter disruptions indicate that central to the concept of home is the extent to which home is defined by excluding*

7 Social class is measured using classifications A, B, C1, C2, D and E (for a detailed explanation, see Tunstall *et al.*, 2007: 20 -21)

undesirable aspects of the outside world and controlling what goes on within its walls (Twigg, 1999; Sims *et al.*, 2009: 306).

What is clear from these pieces of work and other work on the relationship between place and identity (see Twigger-Ross, 2012 for overview) is that disruption to home, its representation and the underlying sense of security that it brings is an important component to consider in developing individual resilience. Interestingly, in the section below on resilience to flooding at a society level, the idea of being able to live with floods is discussed, it may be that this is as hard to implement at the individual level as it is at the planning and strategic level because of the need to protect oneself psychologically from threat.

The role of flood awareness, flood experience and responses to flooding

Whilst the focus of the resilience papers found within the database search is largely at the level of systems, cities and communities there is much work that has been carried out over the past decades that provides useful information on what leads individuals to be flood aware, to prepare and to respond to flood warnings. It would be a serious omission not to refer to this literature and a useful summary of work has been developed by the Environment Agency (2012). The area has been tackled rather in terms of what are the barriers to people taking action in relation to flooding or making themselves "resilient" to flooding, as opposed to those aspects that facilitate resilient behaviours. The area of risk perception, action and flood awareness is one that has been quite extensively studied within the UK in relation to flooding and the findings are derived from case studies as well as analysis of quantitative data (e.g. Tunstall, 2007), so findings can be considered pretty robust. Also it should be noted that a detailed review of flood risk communications is being carried out as part of the development of the Flood Risk Dialogue project which will be a more in depth review of key aspects of flood risk perception and the role of communications.

Very simply there is clear evidence that the link between awareness of flood risk and taking action at the individual level is not straightforward and it cannot be assumed that people will take action because they "know" about a flood risk. There has been a tendency to suggest that "if only people understood that they are at risk of flooding then they would take the appropriate actions", this is what has been termed the "information-deficit" model and as Tapsell (2011) state:

> *The 'information-deficit' model widely used by flood risk managers in the past is said to neglect the socially embedded and contextualized manner in which people make sense of the world. Risks need to be viewed in the context of evaluations of local life and the local environment.*

There is also evidence to suggest that 'those people who are already socially disadvantaged in some way within societies who are particularly vulnerable in terms of being aware of flood warnings, in their ability to receive a flood warning, and in reacting appropriately to flood warnings' (Tapsell *et al.*, 2005: 25). In addition, higher income households are often more aware of and are better able to afford a wider range of technologies, such as access to the internet (Tapsell *et al.*, 2005).

Factors that have been shown to reduce the likelihood of a warning being acted on by individuals include:

- No prior experience of flooding – although the relationship between flood experience and action is complex as discussed below, having no prior experience is linked to lower awareness, preparedness and action.
- A disbelief that it will happen to oneself "Flood risk events may be perceived to be psychologically 'distant' in time and space. And it is known that people tend to have an 'optimism bias' where the risk to oneself is considered to be lower than to people in general" (Environment Agency, 2012)
- Use of local knowledge of the river over expert knowledge in warnings to decide whether or not warnings were serious especially where there was a history of frequent flooding.
- Uncertainty as to when to abandon house; lack of knowledge regarding buildings' resistance to water,
- Uncertainty/ignorance of most appropriate action.
- New residents' ignorance of local flood history.

Prior experience of flooding has been linked to an increased likelihood of receiving a flood warning and undertaking protective actions (e.g. Fielding *et al.*, 2007; Tunstall, *et al.*, 2006). However, Green *et al.* (1994) found that previous experience of flooding does not necessarily buffer the consequences of an event. Frequent or severe flooding may increase anxiety about future events (Werrity *et al.*, 2007; Whittle *et al.*, 2010). Qualitative research findings in England indicate that prior experience can also hinder response and preparedness in some circumstances, for example: some people may not expect a worse event than the one they have previously experienced; some flood victims just want to 'move on' and forget about their experiences, for them undertaking any preparation measure increases anxiety and worry about future flooding; and others, particularly if they suffered considerable damage before, may feel that their actions will not be useful (McCarthy, 2004; Whittle *et al.*, 2010). Fernandez-Bilbao and Twigger-Ross (2009) concluded from their literature review and case studies on recovery and resilience that "*Research shows that only a very small proportion of flood victims are prepared for a future event. The causes of low preparedness range from an understandable wish to move on and reduce anxiety, to feeling that one cannot do anything about flooding*" (EA Science Summary, 2009).

The role of prior experience is complex, and certainly it should not be assumed that if people have been flooded that they will take action to prepare themselves for another flood. Section 6 on interventions picks up on some of these issues further.

In their work for the FLOODSite project, Steinführer *et al.* (2009b – emphasis added) conclude:

> *As for social constructions of flood risk and their consequences for flood risk management, it was found that in order to take any risk reducing measures it is needed that the* ***people are both aware of the risk of being flooded and that they attribute a certain significance to the measures that they take.*** *All of these perceptions and behaviours are related with the people's social constructions of risk. Thus risk is neither simply attributed to a natural hazard nor an objectively given constant. Rather, flood risk is not just a statistical number but also to be understood as being* ***socially constructed*** *in the sense that normative views and values, as well as belief systems, influence and possibly define it.*

Resilience at the community level in relation to flood risk management

> *Communities and individuals harnessing local resources and expertise to help themselves in an emergency, in a way that complements the response of the emergency services* (Cabinet Office, 2011: 11).

We take resilience at the community level in relation to flood risk to have a focus on networks and relationships between people, essentially providing resources and processes that enable groups of people to be resilience rather than individuals The emphasis in the current Pathfinder programme on "community" resilience is part of the general move towards both a more local focus on resilience building and more diffusion of responsibility for resilience from central/local government and agencies to a more multi-actor approach to resilience that puts local people in communities at the centre of resilience building alongside local government and their agencies, third sector organisations and businesses. Defra (2012a) show an understanding of the complexities associated with engaging with communities in the Pathfinder prospectus when they state:

> *Factors to consider when deciding how best to engage with local communities include financial deprivation, age, community cohesion and existence of social networks. Community interventions should apply good practice. This means, for example, understanding the local community, setting clear objectives for engagement with the community, using appropriate methods and materials to engage, and good evaluation to help others who may want to adopt the approach you are implementing through your project* (Defra, 2012a: 4).

However, it is important not to use the term "community" in an unreflective way as both community and resilience are complex multi-faceted concepts it is a difficult task to know which characteristics of community will influence which aspects of resilience and under what conditions. Understanding that communities are rather dynamic, relational and based in interest, geography or circumstance is vital to any discussion of resilience at the community level. Coates (2010a) found in her study on the role of community in flood risk management that the ability of residents to respond collectively to flooding was dependent on the types of local community structures created and the network patterns this produced. These in turn were dependent on the spatial context and the discourses of community employed. Clearly, "*local communities may take very varied forms. It cannot simply be assumed that a community is present, willing and able to take on whatever flood risk managers may require of it*" (Coates, 2010b). Taking a view of resilience that maps out different domains (after Cutter *et al.*, 2010; Norris *et al.*, 2008) should help ensure that the nuances of communities are recognised.

Research suggests a number of related community characteristics which play a role in building resilience: networks: social capital; trust identity and previous experience. Twigger-Ross *et al.* (2011) provide a useful summary which though used in a context wider than flood risk was drawn largely from flood research in the table below.

Table 9: Characteristics of communities which play a role in resilience (from Twigger-Ross *et al.*, 2011)

Characteristics		Key features	Potential influence on community resilience in emergencies
Networks	Bonding social capital[8]	Close knit, family/friends support, could be insular	Likely to provide important "getting by" support in an emergency, but may not be linked to wider resources. If linked into authorities, organisations could provide very useful ways of communicating with local people in emergencies.
	Bridging social capital	Looser networks between people, communities of interest, e.g. work, protest	Can enable people to draw on a wider range of resources during an emergency. Bridged networks may appear after emergencies, galvanised around the emergency. If developed around a number of issues then it provides vital links between different types of people within an area.
	Linking social capital	Hierarchical networks between local people and authorities	If developed they provide the vital relationships between organised emergency responders and local people in such a way that improves responses to emergencies and reduces negative impacts
Trust		Competence, Consistency, Empathy	Crucial to the development of social capital and in governance structures
Identity		The values around which a community coalesces and expresses	Can be useful if the values link with those needed within emergencies e.g. altruism, support for neighbours, but care is needed that assumptions about how people with a shared group identity will work in an emergency.
Previous experience		The experience a community has had of the event	The evidence suggests that previous hazard or emergency experience at both the individual and communal level can play a positive role in building resilience e.g. knowing what to expect, signing up for warnings etc. However, that experience can also 'imprison' communities in the belief that a low probability or 'worst case' event, of greater magnitude than any in memory, will never happen to them.
Community Context		Physical and social features of the community e.g. spaces for communal events, relative isolation and social structures e.g. parish councils	The interaction between the spatial and the social aspects of community can be important in resilience building e.g. if rest centres are outside a person's community they may not go to them in an emergency. Isolated areas may foster a greater sense of perceived resilience and therefore decline offers of help. Key social centres e.g. pubs can provide valuable focus in emergencies.

[8] Social capital here after Putnam (2000)

Smith *et al.* (2011) carried out some research into the role of the 'community' in recovery which highlighted how vulnerable rural householders can be without recourse or access to neighbours and local networks. They conducted questionnaire surveys and face-to-face interviews with farmers (N=39) and individuals responsible for the management of the flood recovery programme (N=17) after severe flooding affected the Manawatu-Wanganui region in rural New Zealand. One of the key findings of the research was that the term 'community' had a complex and contested meaning for those living in the area and it did not necessarily relate to the geographical community. In many instances the experience of the floods was thought to have brought people together with an increased sense of a geographical community. However, respondents reported that those with long-established networks received the most amount of aid following the floods and similarly, organisations with the longest local track record were most accepted to offer support. There was also a reported sense that regional and national institutional response was inappropriate and lacked local knowledge and understanding of the area, highlighting the importance of public participation in disaster planning and recovery.

> *What this paper shows, however, is the urgent need to refocus efforts in order to strengthen local communities and to make them the primary bulwark against any future disaster and to support those agencies currently working towards this end. The resilience of rural communities is shaped by a wide array of economic, social and political drivers that operate in isolation from any debate on resilience or disaster management, but, as shown, it is the coherence and strength of communities that underpin the capacity of individual farm households to respond to adverse events. This suggests a need to harness some of the pioneering spirit of the past to address current needs* (Smith *et al.*, 2011:550).

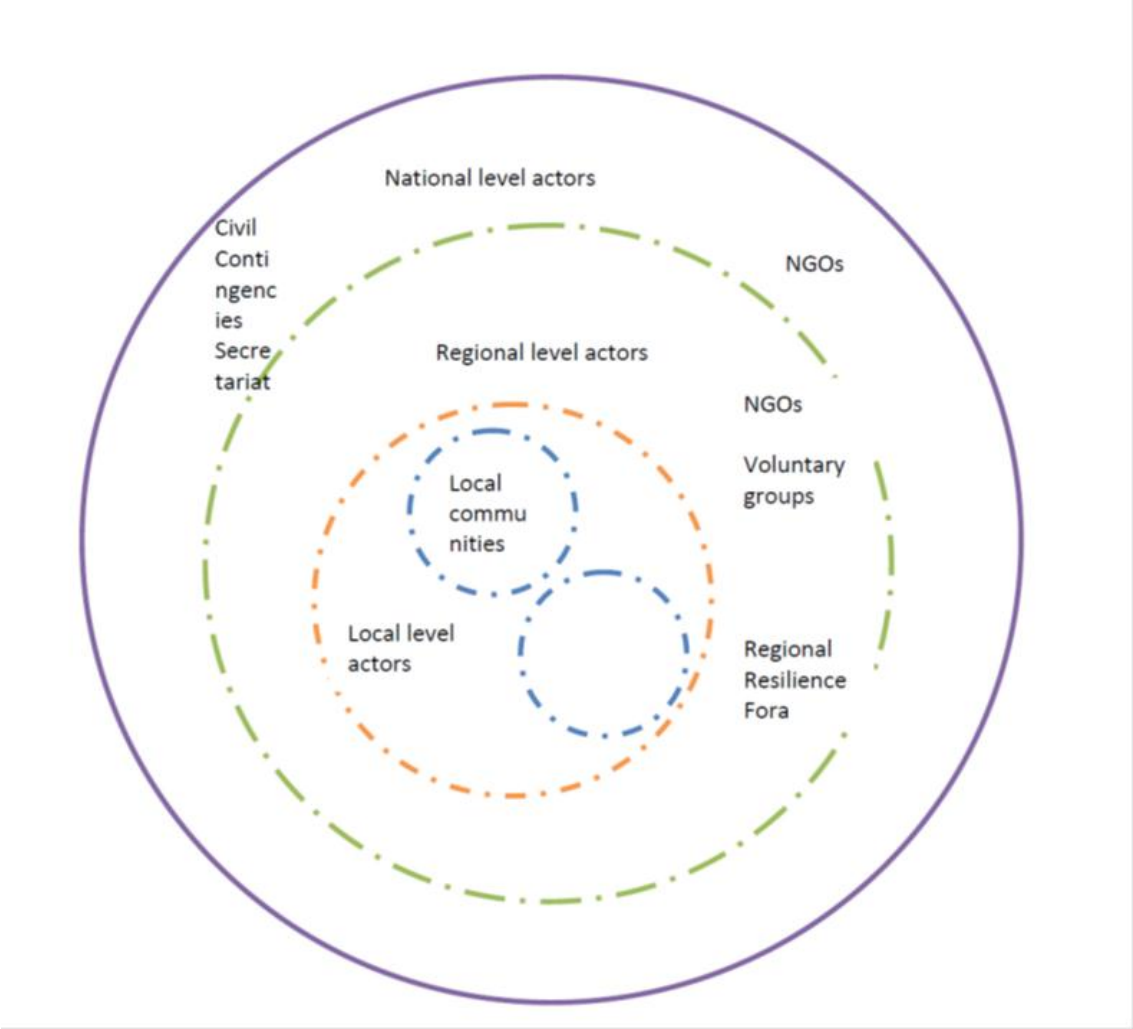
Households exposed to frequent flooding occasionally have the ability to make a choice of living with the risk and disruption that flooding brings and in some cases actually decide to move into an at risk location. Research undertaken with Thames Ditton Island residents as part of an Environment Agency flood alleviation consultation (McCarthy *et al.*, 2006: 20) revealed how residents balanced the choice of living with the disruption of frequent flooding against the amenity of quality of life issues of living in a close knit community in what they considered an idyllic setting. There was a sense that there was a commitment of coping with the flooding to be able to stay in that community: "*One of the elderly ladies went (left the island) because she thought she ought to, she didn't want to go, but she just didn't want to be useless to everyone, so she went for that reason*." Residents were financially and physically able to make that choice. Interviews revealed a sense of the community pulling together and signs of physical and behavioural adaptation were evident but there were also indications that living with flooding did still create an anxiety and required effort.

Resilience at the societal level in relation to flood risk management

We take resilience at the societal level in relation to flood risk management to mean a focus on those actions and decisions that are generated by those working in the flood risk management system who set policies, laws procedures and practices e.g. policy makers, spatial planners, flood risk engineers, emergency planners, elected representatives. It is concerned with governance of the system where governance is defined as the institutions, bodies or organisations involved in decision-making processes together with the structures and norms between them. Increasingly it is more than just 'government' and is likely to consist of a wider range of formal and informal bodies (e.g. flood NGOS, community flood groups). Governance structures are at every stage of the flood risk management cycle

from planning through to incident management. As an example Figure 4 provides a representation of the levels of governance within emergency management relevant to flood risk management in the UK (Twigger-Ross *et al.*, 2011). Similar representations of governance can be made for other aspects of FRM (e.g. spatial planning).

Figure 5: Representation of the levels of governance within emergency management of flooding in the UK



The current approach to governance of flood risk management in the UK is one of devolving power down to the local level and emphasising the role that individuals and communities have in helping themselves to be resilient to flood risk management. To do this effectively requires flexible and responsive forms of governance. Wardekker *et al.*'s concept of "flatness" is a key one as it points to the need for governance systems that can respond quickly and don't rely on long chains of command up through a central point. Kuhlicke (2013) in his discussion of a constructivist approach to resilience on how people makes sense of their experiences in a flood, what narratives are developed, opens the discussion on resilience to questions of interest, power and social conflicts which again brings in the question of governance. Twigger-Ross *et al.* (2011) summarise recent social science literature on governance to suggest that the factors that influence community resilience in emergencies in general are:

- **Diversity**.. of actors and structures in the governance structure: greater diversity likely to mean a wider range of resources to be drawn on in emergencies.

- **Autonomy**.. of actors and structures: autonomous components likely to be more resilient.
- **Interdependence**.. of actors and structures: ability of each actor/structures to support each other.
- **Adaptability**.. of actors and structures to learn from experience: more adaptable actors and structures will increase resilience.
- **Collaboration**.. between actors and institutions: partnership working between sectors brings in a wide array of resources to draw on.

These factors echo some of the characteristics of resilient systems discussed in the earlier section. Wardekker *et al.* (2010) is a useful paper to consider here although its focus is wider than flooding, as it covers climate change risks but it is a useful exploration of how resilience policies and practices can be developed. It follows through from resilience characteristics to policy options, in the very real context of the city of Rotterdam which faces a number of climate change impacts: sea level rise, particularly in combination with storm surge, and enduring heat, and drought. The discussion of potential disturbances (i.e. climate change impacts) and options for adaptation reported on in the paper were generated through a combination of interviews and workshops and focus on the structural, planning, informing and warning aspects of resilience. The participants were all "experts" and the emphasis then is on actions that could be carried out by those in places of power at the level of the city rather than in individual actions. Each of the principles described in above were discussed by the participants and illustrative (rather than exhaustive) options that could be considered within a resilience approach to climate change adaptation in the area were developed.

Box 4 gives a flavour of the way this worked for three of the resilience characteristics:

Box 4

"Homeostasis involves incorporating feedback loops that stabilised the system to external perturbations. One set of options suggested by participants involved the removing of the feedback loop of "unclear responsibilities" [between government and residents, between different organisations] by establishing clarity on the responsibilities and (financial) liability in case of flooding. Water damage should be insurable and people could be rewarded for accepting occasional or regular water-related problems".

"High flux allows for quick responses to threats and changes. One way to implement high flux would be to shorten the planning horizon for buildings, and urban planning in general. For instance, one could plan for houses to be replaced after 30 years rather than 50; thus ground level can be elevated / modified more quickly. This can be combined with a 'cradle-to-cradle' approach and the use of modular elements in buildings; building a "rebuildable city". If elements of constructions could be reused or deconstructed and later rebuilt, the area could be modified relatively quickly, and at lower costs, to accommodate changing conditions. Other suggestions included: quick notification of high tides, allowing residents and officials to take measures early on (high flux of information), and planning 'green areas' and other quickly-modifiable land-uses in areas where future changes may be required (high flux of land use)."

"Flatness involves preventing the system from becoming top-heavy, over hierarchical. In top-heavy systems early warning signals observed at the bottom reach higher levels too slowly due to long or complex/noisy lines. When decision –authority lie at these higher

levels, decision power and reaction capacity are severely limited. In the context of socio-ecological systems, this would involve overly complex procedures for decision making bureaucracy, and a limited influence of local actors on policy...Options can be divided into two groups. First, the population should be able and be allocated the competence and power to respond to possible problems. .....Second, policymaking should be made more participative and tailored to the local situation."

"Buffering entails the ability to absorb disturbances to a certain extent. In the context of flooding hazards, certain (non-essential) low-lying places could be planned to serve as water retention areas for a limited period, until high water tides are reduced. The concept of "water squares" is already in use in Rotterdam's water policy plans" (Wardekker *et al.*, 2010: 993).

Whilst the options developed have not been put into practice or evaluated they show a clear way of working with resilience characteristics and exploring how they would work in practice.

Liao (2012), in a similar way to Wadekker *et al.* (2010: 48), aims to operationalise resilience theory in a real world example, looking specifically at urban resilience. She takes the debates within resilience theory discussed above (i.e. the move from resistance to transformation) and considers what that might look like in relation to flood risk. She suggests that "*Flood hazard management based on resilience theory would begin with acknowledging periodic floods as inherent environmental dynamics, by which socioeconomic activities on floodplains are inevitably affected*."

Resilience in the context of flooding is considered by Liao (2012) to be about managing uncertainty, variability and shocks which are considered inherent to the socio-ecological system. Given this, she suggests that if environmental stability (i.e. no flooding) is the goal and the foundation of the social and economic life of the city, then that city would be more resilient if periodic flooding is acknowledged as normal and affecting economic and social activity. Her point is that the focus should be on managing uncertainty and change in both physical and social systems. She also suggests that learning from ecosystems we can say that a little bit of flooding creates an opportunity to learn and adjust. In this way "*flooding is itself an agent for resilience because each flood experience creates a chance for cities to adjust in process and structures*" p. 48. Certainly there is evidence for how floods in the UK have created changes in policy and practice (Johnson *et al.*, 2005). The Pitt review (2007) in its comprehensive review of the 2007 floods provided several new foci for flood risk management specifically: critical infrastructure, recovery and better integration across government agencies.

Liao (2012) goes on to suggest that urban resilience to flood can be measured using "floodability" together with the capacity for quick reorganisation of institutional/social life. Floodability she suggest could be assessed by measuring the amount of floodable land in a city suggesting that if there is floodable land (i.e. land that is not damaged when it is flooded) then a flood becomes more benign, the water has places to go. The paper remains theoretical, but does provide a next level down in conceptualising what flood risk management of a city might need to focus on.

Both Wardekker and Liao go beyond considering incident management but move into the consideration of spatial planning and the organisation of economic and social life in a city. In both cases the suggestions for organising resilient cities focussed on options that

improved both the short term management of flood risk as well as developing longer term solutions for flood risk management.

To what extent and in what way is resilience being conceived within plans or strategies? Davoudi *et al.* (2013) examine how resilience is operationalised in the Draft Climate Change adaptation strategy for London. Drawing on resilience literature Davoudi *et al.* outline three perspectives on resilience: engineering (focus on resistance), ecological, (focus on maintenance of stability and ability to return back to normal) and socio-ecological (focus on adaptation and transformation of systems). They use the term evolutionary resilience to describe their version of socio-ecological resilience which has four components: persistence – being robust; preparedness- learning capacity; adaptability – being flexible and transformability – being innovative. The four components incorporate and build on the engineering and ecological resilience definitions and are used by the authors to analyse the plan and the interview material. From their analysis they conclude:

> *The Strategy's emergency planning-centred approach to climate adaptation veers between a standard ecological understanding of resilience and the more rigid engineering model. Its emphasis is on identifying 'exposure' and 'vulnerability' to risk from climate events and on bouncing back from the consequences of such exposures to a normal state, rather than on the dynamic process of transformation to a more desirable trajectory. The study concludes that fostering resilience involves planning for not only recovery from shocks but also cultivating preparedness, and seeking potential transformative opportunities which emerge from change* (Davoudi *et al.*, 2013).

What does resilience look like in practice in relation to flood risk management? Are there examples of resilient communities?

In this section we present two broad approaches to thinking about resilience in practices: firstly those papers that focus on presenting an ideal of what a resilient community might look like; and secondly, examples of flooding where aspects of resilience can be seen within those communities.

Bahadur *et al.* (2010), in the context of disasters generally, present 10 main characteristics of resilient systems, which are presented in Box 5. These characteristics take the systems approach but ground them in more of societal framework providing one idea of what a "resilient system" might look like Clearly this builds on work discussed in the previous section and what is clear is that the characteristics are spread across the domains of social, economic, infrastructure, institutional and community capital reinforcing the multidimensional nature of resilience.

Box 5

Ten main characteristics of resilient systems:

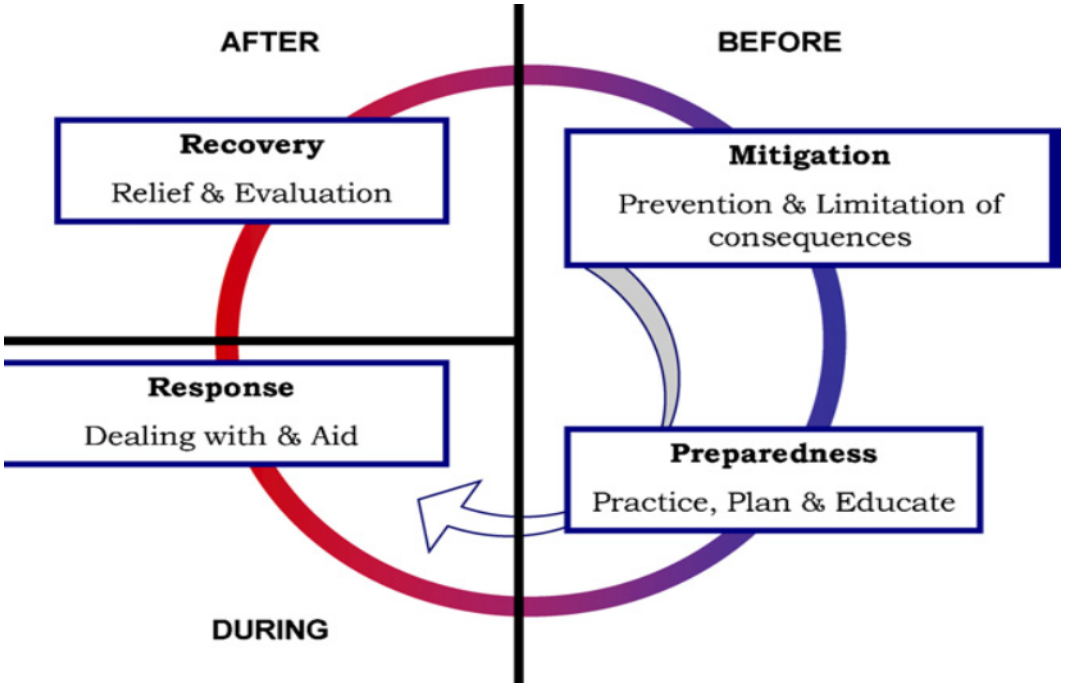
1. A high level of **diversity in groups** performing different functions in an ecosystem; in the availability of economic opportunities; in the voices included in a resilience-building policy process; in partnerships within a community; in the natural resources on which communities may rely; and in planning, response and recovery activities.

2. **Effective governance** and institutions which may **enhance community cohesion**. These should be decentralised, flexible and in touch with local realities; should facilitate system-wide learning; and perform other specialised functions such as translating scientific data on climate change into actionable guidance for policymakers.
3. **The inevitable existence of uncertainty and change is accepted**. The non-linearity or randomness of events in a system is acknowledged, which shifts policy from an attempt to control change and create stability to managing the capacity of systems to cope with, adapt to and shape change.
4. There is **community involvement** and the appropriation of local knowledge in any resilience-building projects; communities enjoy ownership of natural resources; communities have a voice in relevant policy processes.
5. Preparedness activities aim not at resisting change but **preparing to live with it**; this could be by building in redundancy within systems (when partial failure does not lead to the system collapsing) or by incorporating failure scenarios in Disaster Management (DM) plans.
6. **A high degree of social and economic equity** exists in systems; resilience programmes consider issues of justice and equity when distributing risks within communities.
7. The importance of **social values and structures** is acknowledged because association between individuals can have a positive impact on cooperation in a community which may lead to more equal access to natural resources and greater resilience; it may also bring down transaction costs as agreements between community members would be honoured.
8. The **non-equilibrium dynamics** of a system are acknowledged. Any approach to building resilience should not work with an idea of restoring equilibrium because systems do not have a stable state to which they should return after a disturbance.
9. **Continual and effective learning is important**. This may take the form of iterative policy/institutional processes, organisational learning, reflective practice, adaptive management and may merge with the concept of adaptive capacity.
10. Resilient systems take a **cross-scalar perspective** of events and occurrences. Resilience is built through social, political, economic and cultural networks that reach from the local to the global scale.

In the context of flooding, Schelfaut *et al.* (2011) after ten Brinke *et al.* (2008) suggest:

> *The defining and thus taken-for-granted characteristic of resilient communities is the ability to reduce, prevent and cope with the flood risk. Resilient communities have improved their capacity in each phase of the flood management cycle [as shown in Figure 6 below]. They are knowledgeable and aware of the risk, are well-prepared and respond better when a flood occurs, and recover more quickly from disasters* (Schelfaut *et al.*, 2011: 826).

Figure 6: Resilience through the flood risk cycle (Schelfaut *et al.*, 2011)



Their study of three European countries looked at the extent to which, flood damages could be avoided by increasing flood resilience. The paper suggests three aspects of flood risk resilience that can be increased and suggest some potential measures which are reproduced below for information. These measures were evaluated within the FREEMAN European project and provide a useful example of an approach to increasing flood resilience from a number of perspectives. Again, it can be seen that resilience is built across a number of domains, in this case: institutional, economic, and infrastructure levels.

Table 10: Measures for increasing resilience

Domain	Measures
Risk communication & perception	Residents: risk communication strategies, e.g. flyers, targeted campaigns to vulnerable groups, self-organisation and informal ways of communication and collaboration. Authorities: risk communication, e.g. training, capacity building on proper communication, guidance documents, actively involve stakeholders, community or business owners.
Flood policy & institutional interplay	Residents: permits, house owner rights, financial incentives (e.g. insurance). Authorities: enforcement of legislation, participatory cooperation, more effective planning, guidance documents, actively involve stakeholders, allocate proper resources, political commitment, legal base (e.g. WFD).
Flood management tools	Residents: promote community action (stewardship), prepare home for flooding (sandbag). Authorities: plan dikes, levees, dams, retention basins, technical development of tools (e.g. lead-time), increase utilisation of tools, capacity building on warnings and tools, guidance documents,

Domain	Measures
	integration of technical knowledge with contingency plans, provide guidance on flood resilient constructions.

Harries (2008; 2012) drawing on his work evaluating property level protection considers how a resilient society might view flooding. Harries (2008) argues that underlying the notion of "blaming the authorities" is the representation of the state as "*fundamentally just and competent, in spite of the failure to prevent a particular occurrence of flooding"* p. 486. He argues the representation of the state in this way enables the preservation of "ontological security" for some who have been affected by flooding. This representation would not be needed for a society that has "normalised" floods as individuals and communities would not regard floods as necessarily disastrous events and would know that they can recover from them. This aspect of resilience is about a shift towards acceptance of uncertainty and change which is one of the characteristics in the DFID list. It is a crucial issue and though the resilience dimensions highlighted above include adaptability and transformability which imply a shift towards acceptance of flooding there is little discussion of how that might happen in practice and would be a useful area for further study.

Twigger-Ross *et al.* (2011) provide two case studies of flooding in the UK (Thirlby - flood and Great Yarmouth - near-miss, evacuation) that show aspects of what resilient communities might look like, focussing on the role of social capital in building resilience. Box 6 and provide summaries of what happened in the events and afterwards based on case studies carried out (Twigger-Ross *et al.*, 2011).

Box 6

Case example: Thirlby, North Yorkshire

In June 2005 intense rainfall occurred in the south west part of the North York Moors, causing the flooding of 121 properties. Thirlby, a small village of approximately 120 people was under the area of most intense rainfall and flash flooding destroyed a bridge and washed away some of the roads. Access was very difficult during the flood, help didn't arrive immediately, and eventually a helicopter was used to check on the village. The flood waters subsided within hours and after that access was difficult but possible. Approximately 18 properties were directly affected, in one case flooding reached ceiling height and the owners had to escape through an upstairs window. Some of these affected were out of their properties for over a year. There was no history of flooding and no flood plans in place. Residents of the village carried out most of the immediate clearing of trees and other debris. They helped one another to reach higher ground and to move cars. They also provided temporary accommodation, washing, shopping, and meals. They also helped look for lost items and provided small repairs to properties where possible. The authorities were involved with repairing the roads and bridges but there has been relatively little contact with residents and authorities with the exception of the Chair to the Parish meeting who provided the main link between the village and 'outsiders'. Residents felt that they had coped well; they were able to clear up in the immediate aftermath and support one another physically and emotionally in the longer term. Whilst the extensive community events were initially reduced they returned to 'normal' and continue to thrive six years after the flood. Contact with the authorities was limited and the relationships not always successful. The authorities and other organisations such as service providers (and little distinction is made between the two) were generally seen as slow and inefficient. (from Twigger-Ross *et al.*, 2011)

Box 7

Case example: Great Yarmouth, Norfolk

This case study centres on the 8th/9th November 2007 tidal surge and consequent danger of widespread flooding of the Great Yarmouth area. The tidal surge of up to 3m made its way down the North Sea and there was the possibility of it coinciding with peak high tides. There was a risk of flood defences being overtopped on the coast and the tidal rivers in Great Yarmouth as well as other areas in East Anglia. There were severe flood warnings issued by the Environment Agency at Great Yarmouth and on parts of the Rivers Bure, Yare, and Waveney all of which flow out to the sea at Great Yarmouth. Over 1000 people were evacuated to rest centres and approximately 40,000 sandbags were given out to local people. Fortunately the weather changed and the flooding did not happen, but the plans were activated. After the event there was a clean-up of sandbags and of the rest centres that had been used.

Local people helped each other as they could in terms of supporting those who evacuated, getting sandbags and looking after people's possessions. There was a sense of the local people not feeling prepared and that the communication between them and the emergency services could have been improved. The emergency services worked together to carry out the evacuation and distributing sandbags including getting more sandbags from other authorities. Police came from other authorities to knock on doors and support the process. Rest centres were set up and rest centre managers were brought in from outside the area.

Since the "near miss" a number of developments have happened to support community resilience most notably the setting up of four community resilience groups around the four urban areas. The aim of these groups is to be the interface between the local people and the different groups (e.g. Homewatch, youth clubs, schools, tenants and resident associations). These groups are variously developing their community resilience plans with a focus on the development of communication trees that could be used in an emergency situation. In addition, in October 2011 one area had an "emergencies week" where they engaged with older people through stories of the 1953 flood and children from the local primary school raised awareness through a loud and noisy walk through the area, asking people if they were prepared and handing out leaflets. There were also events at the school to draw in parents.

Specifically, the case studies provide a number of examples of how different types of social network worked during the different flood events. There was evidence of bonded networks being drawn upon in different ways through helping with tasks during the flood and after. The bonded networks we drawn from very local geographic areas and helped people muddle through in Great Yarmouth but in Thirlby people felt much more self-reliant and competent to get on with it themselves. Bonded networks were partial however and in that sense cannot be relied on as given.

With respect to bridging capital, after the event there have been links between networks specifically in Great Yarmouth with the setting up of community resilience groups and linking this into community development work. This is a good example of how the building of resilience can address existing vulnerabilities (lack of voice, engagement of certain parts of the community). From this, linking capital has been developed between the

emergency planning officers through to the local residents via the community resilience plan which has put in place a communications tree that is activated within an emergency. What seems to emerge from Great Yarmouth is that there need to be proactive (linking) measures taken to facilitate bridging capital otherwise there is a risk that pockets of bonded social networks will be left to fend for themselves and that those who are not socially connected at all are likely to face particularly disproportionate and unfair impacts. Reslience seems to be developed through all three types of social capital working together.

In their qualitative study of a regularly flooded town (flooded in 1990; 1997; 2008) in Australia, Keogh *et al.* (2011: 719) found that "*Charleville was found to be staunchly resilient, with high levels of organisation and cooperation, and well-developed and functioning social and institutional networks. The community is committed to remaining in the town despite the prospect of continued future flooding*." What was a key factor in their resilience was the social capital within the town and the strength of networks. Further many of the residents saw flood risk as their responsibility and had over the years become accustomed to taking measures to prepare for the flood. In addition, the residents were confident that the officials were also prepared for flooding, so important relationships of trust were apparent. There were some vulnerabilities in the town with the main one being the low levels of insurance cover (32% residents; 43% businesses) but even so people said they did not want to leave the town and were conscious of the impact of leaving on the wider community.

Andrew (2012) provides a useful discussion around building community resilience drawing on an analysis of a number of recent UK floods (Boscastle, 2004; Gloucestershire, 2007; Cockermouth, 2009 and mid-Cornwall 2010). He draws out the interrelationship between the formal institutional structures e.g. the legislative framework for emergencies in the UK: "gold", "silver" and "bronze" command that are set up during the response phase, and local communities highlighting the importance of both to building community resilience. Of communities Andrew suggests that they are important because they have local knowledge about floods but also know where vulnerable people live as well as having access to local resources and equipment that might be of use during an emergency e.g. chainsaws, four by fours etc. Although this paper does not situate itself within the academic resilience literature, it has an implicit model of resilience that is adaptive ("bounce back better") as Andrew (2012: 64 – emphasis added) suggests:

> *The community perspective can be separated into three distinct processes – response (the blue-light element), then recovery (the clean-up) and then building future resilience (what can be done to mitigate in the future), with each following the other. It has been demonstrated that to be fully effective, these elements must not be run in isolation.* ***In particular, the response and recovery stage should be concurrent and learning and knowledge, both at the strategic level, need to be brought together to inform future events and build resilience.*** *It has also been shown that consideration should not only be given to the physical infrastructure, but also to the social infrastructure; in addition, recognition should be given to the vital role that local communities play.*

Andrew echoes definitions of resilience and brings out the learning aspect needed to build resilience into the future. One of the cases he describes is reproduced below in Box 8 to give a flavour of how the community and emergency services worked within the emergency and afterwards.

Box 8

Case example: Mid-Cornwall 2010

On 18 November 2010, large areas of rural mid-Cornwall in south-west England covering an area of over 250 km^2 experienced severe flooding. Within just a few hours over 60 mm of rain fell and resulted in closed roads and destroyed infrastructure. Over 500 houses and 100 businesses in a number of villages and hamlets were flooded. A 'silver' control centre was opened to manage and coordinate the multi-agency response with the police, fire and rescue service, highways, environment agency and other key partners. On the day of the event the community flood recovery group was established and arranged local public evening meetings in Lostwithiel St Blazey and Mevagissey, with over 30 members of the public at each. Representatives from Cornwall Council (including the localism, public health and protection, housing and highways services), Environment Agency, police, health, Royal Society for the Prevention of Cruelty to Animals (RSPCA), local parish council and the faith community gave advice about the immediate clear up. An information pack was produced and distributed among the affected communities by the end of the first day of the floods. This provided contact details of useful organisations and general advice on how to deal with the impact experienced by flooding, including how to stay healthy and clear up following a flood. The day after the event the group coordinated visits with Prince Charles and prime minister David Cameron during the afternoon. The visits had a significantly positive impact on the morale of those affected by the flooding. The group continued to provide practical support and advice to local communities during this time. In addition, a local flood support fund was established by Cornwall Community Foundation to coordinate financial donations and distribute locally. The team continued to provide part-time cover at community contact points until Christmas 2010, working with the Out and About Service where possible to manage offers of help and to coordinate the delivery of flood aid equipment. The Women's Royal Voluntary Service (WRVS) volunteer organisation instigated a 'door knocking' programme in the three main affected communities and coordinated multi-agency visits to the outlying communities of Portloe, Veryan, Port Holland and Polmassick. In December a local 'community flood plans' meeting was held with the affected communities and, as a result, six communities started developing a plan. Additionally, a debriefing event was hosted with local communities to review the outcomes and to look at future solutions. In May 2011, the Environment Agency provided funds on behalf of the UK government to deliver a programme of individual household protection measures. Cornwall was allocated £582,000 to work in the area affected − over a quarter of the total money allocated to communities nationally.

These papers provide a view from a range of different perspectives as to what a resilient community might look like. Pomeroy (2011), in her work on community resilience in rural New Zealand, found that community members expressed (in focus groups as well as individually) the following attributes as those of resilient communities:

- Enduring, having staying power
- Being tenacious, having 'stickability'
- Adaptable, flexible, adapting to change and opportunities
- Being able to bounce back
- Absorbing life and thriving
- Strong, robust

- Stoic
- Self-sufficient
- Resourceful
- Staying in the community and on your land despite circumstances
- People having a sense of belonging, ownership and pride in their community, and actively participating in community affairs and activities
- Being able to tough it out when everything is going wrong, such as when there is no money coming in, and floods or drought hits
- Being open to change and diversity (tolerant and accepting difference), and coping with change at individual, family and community levels
- When something happens we pick ourselves up and move on
- We pull together as a community when there is a crisis
- Having confidence and self-belief in your own, and your community's ability to cope having a vision that provides motivation and a goal to work towards recovering quickly and bouncing back after a crisis. It's that 'can do' attitude.

What is interesting here is seeing how the perceptions of what resilient community might look like fits very well with the more formal definitions expressed for example through the Bahadur *et al.* (2010) list of characteristics.

How is resilience created within communities in relation to flood risk?

From the discussions in the previous sections, clear suggestions emerge as to how resilience is created with communities in relation to flood risk. Firstly, it resilience to flooding is inextricably linked to capacities, capabilities, processes that exist on a day to day basis within a community. The "inherent resilience and vulnerabilities" (Cutter *et al.*, 2008) are vital for the development of resilience to flooding and other emergencies. However, it is also clear that there are specific capacities that are needed in order to be resilient to flood risk from knowledge of flood risk, actions to take in a flood, development of emergency plans through to longer term planning of settlements that can mitigate flood risk.

In more specific terms we would suggest that all aspects of the resilience definition and its dimensions provided by the ENSURE project are relevant for developing resilience: robustness, adaptability and transformability. These dimensions need to be developed in each of the different resilience domains/capacities described by Cutter *et al.* (2010): social, economic, infrastructure, institutional and community capital. Taking a systems approach to flood risk management means that all these aspects will need to be included in resilience building.

Resilience building in relation to flood risk needs both formal and informal social structures and processes and importantly requires clear linkages and accountability between those structures, so that resources can be freely transferred and exchanged. Community resilience cannot be built in a vacuum.

Secondly, floods themselves provides opportunities to create resilience, the emergence of groups, structures and activities is clearly illustrated by the examples of Great Yarmouth, Thirlby and Hull. What is important is working out how to translate those temporary relationships into longer lasting aspects of resilience. This aspect of emergence points out the dynamic nature of resilience: which we should perhaps be talking about developing processes of resilience rather than expecting resilience and as an outcome, that is achieved once and after that does not need to be addressed. Research reviewed here strongly suggests that creating resilience to flooding is an ongoing process of adaptation and learning from past events and to future risks.

Finally, discussions of resilience lead to discussion more generally about how we develop sustainable communities and any discussion of resilience to flood risk should at some point link into these wider debates:

> *It may even be advantageous to widen the scope beyond resilience, and to advocate strengthening communities for a whole range of reasons, or alternatively, to incorporate civil-protection focused resilience building into ongoing community-focused activities (e.g. 'Transition Towns' groups). This could bolster people's desire for local community solutions by highlighting the potential 'emergency situation' benefits to locally based groups, who get together for a variety of other reasons (e.g. to make improvements to local area or to improve local networks), because it has the potential to increase community safety through local people knowing each other's vulnerabilities, resources and skills* (Twigger-Ross *et al.*, 2011: 35).

6. What is known about Interventions to Build Resilience to Flood Risk Management?

Introduction

In this section we report on research evidence regarding recent developments in flood risk management and, in particular, new 'interventions' for the promotion of improved flood risk management. However, these are not interventions in the traditional scientific meaning, they are interventions in the sense that they are attempting to create new ways of practising flood risk management, involving key stakeholders and creating new knowledge. This approach is taken because the traditional type of interventions that might be used in health study (e.g. random control trial of a new drug for cancer) were not found in the evidence examined. We also report on research that highlights barriers to resilience. The database search together with input from our experts identified 58 potential papers for us to consider which as discussed in Section 4 was reduced to a core 18 for review which we present in this section. Using Norris's (2008) types of resilience as our categorisations scheme the majority relate to interventions designed to develop institutional resilience, with a few on developing infrastructure resilience and community resilience. As yet we have not identified papers relating to increasing economic resilience. We do know there is work in this area (e.g. ENSURE project) but in the published literature review nothing substantial emerged. As suggested in our refinement of research question of financial resilience we suggest this is better suited to a review that looks outside of the flood risk management literature and draws in relevant findings. We begin with looking at recent papers on risk perception and preparedness which set the scene for our later discussion.

As flood mitigation measures solely reliant on structural flood mitigation measures are no longer seen as being the sole source of resilience to flooding, there has been an increasing exploration of potential avenues for introducing non-structural measures, such as flood proofing, flood insurance, improved land use planning and flood forecasting and warning. There has also been a policy shift in locating responsibility for risk reduction and protection solely from public authorities to one where individuals share in the responsibility, which has been termed 'the privatisation of risk' (Steinführer *et al*., 2008). The European Floods Directive (2007: Article 10) calls for public involvement in flood risk management by stating that "Member States shall encourage active involvement of interested parties in the production, review and updating of the flood risk management plans". Yet there are challenges with this new approach, one of which relates to the public's perception of their role. Steinführer *et al.* (2009a) carried out research in Germany, Italy and the UK using questionnaire surveys (secondary analysis in the UK), focus groups and discussions with decision-makers and members of the communities affected by flooding. The research preceded the 2007 Directive but was focused on issues of social vulnerability and resilience.

> *…our empirical findings underline that recent developments in the policy sector are not shared (or even understood) by the people at risk. While the demand that individuals should take responsibility and adopt private precautionary measures seems relatively well established within the scientific community and among flood-risk managers the results of our research show that among the residents at risk traditional assumptions about flood protection predominate: They are very much in favour of technical solutions ('structural measures'), and in their point of view flood protection needs to be borne by public authorities* (Steinführer et al 2009b:9).

Risk perception and preparedness

Section 5 has discussed some key findings on risk perception and risk preparedness. In this section we look in detail at a number of studies to pull out the implications for designing interventions to increase risk awareness, preparedness and actions. Bradford *et al.* (2012: 2299) conceptualise risk perception as a "pillar of social resilience" meaning that understanding how people perceive risk is important for the development of risk communications that are trusted and acted upon by individuals so as to improve their resilience to floods. After Raaijmakers' (2008), model of risk perception, the authors characterise risk perception as a combination of awareness, worry and preparedness. They carried out quantitative research with 1375[9] participants in thirteen communities at risk of flooding across six European countries (Finland, Ireland, Italy, Scotland, Germany and Belgium) and conducted in-depth case studies with sub-cohorts in individual countries.

They found that 80% of respondents (total n= 1375) were aware of their flood risk and that this awareness was correlated to previous flood experience (total n = 1375). However, they found no statistical relationship between awareness and flood preparedness, (total n= 1271) suggesting that strategies relying solely on awareness raising will not necessarily increase levels of preparedness. In line with previous research discussed in Section 5, they did find a statistically significant relationship between previous flood experience and preparedness (total n = 1271). They also found high levels of worry amongst respondents (65% of 795), but found no significant relationship between worry and preparedness. The authors suggest that worry alone does not motivate preventive behaviour. However, this is perhaps an overstatement of the finding. No relationship between these two variables is surprising, one might expect that people who are prepared are less anxious but that does not always appear to be the case. What is interesting is that there was a relationship between increased worry and knowledge of evacuation routes which in turn was related to people feeling more prepared. What is does suggest is that the relationship between worry and preparedness is not straightforward and that risk communication strategies relying on provoking fear alone are not likely to increase preparedness and resilience. The role of emotions such as anxiety in the perception of risk in relation to flooding is an area that would benefit from more detailed research. Soane et *al.*'s (2010:3035) analysis of survey data from 2100 UK homeowners casts some light on these issues. They conclude that risk

[9] It should be noted that not all questions were asked in all countries, so the sample sizes varies across questions. Where relevant this is highlighted.

perception only leads to property level protection if homeowners have a sense of responsibility and agency and believe that their efforts will be "worthwhile".

A further finding from Bradford *et al.*'s research is that some respondents (118 of 1375) were not aware of their risk despite having experienced flooding in the past. Focusing specifically on the Irish case study, where they mapped responses to locations they found that these respondents lived in areas adjacent to structural flood protection works that had been put in place since the last major flood event. The authors suggest that the residents had developed a false sense of security believing themselves to be immune from future flood risk. Soane *et al.* (2010) argue that responsibility, agency and belief in the effectiveness of protection measures sometime reduce with experience of flooding; they assert therefore, for more dissemination of evidence of effectiveness. Again this confirms past research and also highlights the need to further unpack the relationship between experience and future action.

As part of the same research project, O' Sullivan *et al.* (2012) report on 11 case studies in four European countries (Finland, Ireland, Italy and Scotland total n= 1142) that used quantitative and qualitative methodologies in communities that were at risk of flooding. They highlight a tendency for respondents to leave mitigation to external agencies rather than taking ownership of the risk themselves, despite their having high levels of awareness and worry. They suggest that flood risk communication ought to clearly outline the remit and responsibilities of all agencies involved in flood risk management in order to encourage reflection on what individuals can do for themselves.[10]

They also find that whilst there may be a vast amount of online official resources pertaining to floods (for example, in relation to risk, warnings and preparedness) only a small proportion of at risk householders are aware of these websites, even amongst people who have been previously flooded. Only 25% of all respondents in the Scottish, Italian and Finnish case studies had such awareness, and the figure was just 9% in the Irish case studies. In all areas, those over 65 and those with lower achieved educational levels were found to be less likely to access websites for this type of information. Only 25% of respondents from the Finnish, Scottish and Italian samples (n = 906) mentioned websites as one of their preferred means of obtaining such information and in relation to other methods (in person visit, email, text to mobile phone, phone call, radio, TV) it was the one fewest people said was their preferred method for receiving flood information and warnings.

Furthermore, all the case studies in O'Sullivan *et al.*'s research showed that there were low levels of understanding of the probabilistic terminology used by some engineers and government agencies. This indicates a need for different approaches to communicating risk. Bell and Tobin (2007), support this finding and suggest that flood risk communication may be more effective if specific physical references (e.g. physical indicators of projected water depth) were used (see also: Ibrekk *et al*., 2005).

[10] Note: the Floods and Water Management Act 2010 provides clarification on these roles.

However, one problem highlighted by Douglas *et al.*'s (2010) study Heywood, Manchester, is that in the case of pluvial flooding[11], it has not always been clear to authorities, let alone households, who is at risk and who is not, or even what the probability of a flood event really is. They gathered data from 44 of 100 households that had been flooded by one or both of two flood events in 2004 and 2006, carried interviews with key stakeholders and held a workshop for 35 organisational stakeholders. This lack of clarity is partly because of the nature of pluvial flooding which is very difficult to forecast for and at the time of this research there were no flood risk maps for pluvial flooding but also because responsibilities for flooding are divided according to type of flooding and this type is the responsibility of the local authority rather than the Environment Agency. Those who were interviewed said that they had seen the first event as unique and has not considered it to signify an ongoing risk. Even following the 2006 flood, uncertainty remained about whether affected properties were at risk of future flooding or not. One resident is reported as having asked at a public meeting, "How many times do I have to be flooded before I am at risk?" (Douglas *et al.,* 2010: 119). Lack of collective (between the institutions responsible and the community members) understanding of the level of risk is demonstrated.

Similar to O'Sullivan *et al*. (2012) that across four European countries that some respondents lacked clarity regarding the roles and responsibilities of agencies engaged in flood risk management, the respondents in Douglas' case study reported not being aware of the roles and responsibilities of different agencies in relation to pluvial flooding. Having interviewed key stakeholders and conducted a workshop to discuss the floods with 35 stakeholders, Douglas *et al.* (2010:123) conclude:

> *The Heywood study has shown that the plethora of agencies, combined with the fact that many public services are now in the private sector, creates a lack of cohesion and invariably constrains effective responses to urban pluvial flood events. There is also a tendency for one agency to apportion the blame for flooding (or a lack of response to it) to another agency*.

Douglas *et al.* (2010) interviewed 44 affected households and found that virtually none had considered physical resilience measures until after the 2006 flood, and one year on, only 27% of those had installed, or were installing, such measures in their properties. Some interviewees expressed a belief that nothing could be done to mitigate the effects of flooding, others said they did not know what measures to take, some of whom claimed to have asked for help from the local authority but to have received no response. There were reported confusions about what measures were in fact effective, and some householders expressed the opinion that it was not their responsibility to take mitigation measures but the local authority's. Some residents also expressed a concern that they would be more prone to burglary if they installed measures when out of their home as this would give a clear indication that they were away. Some of the research participants also cited the cost of flood mitigation measures as the reason for not taking action.

[11] Note that Douglas's research was carried out before the Environment Agency published its surface water flood risk maps which went live in December 2013.

Deeming et al. (2012) approach the issue of perceived responsibility for flood risk mitigation from a slightly different angle. They suggest that the problem lies in the fact that the recent shift toward flood risk management follows many decades (or even centuries) of flood hazard management (Johnson et al, 2005). Flood hazard management, Deeming et al. suggest, was understood as meaning that 'the powers that be' could always tame errant hazards, a philosophy that could be argued to have led to society's sustained encroachment onto the floodplain. This narrative, they suggest, allowed the hazard-exposed publics to develop a 'trust in authority' (i.e. "I declare my dependence on you" rather than the "I have trust in my relations with you" that signifies social trust), which is still effectively preventing them from engaging fully with the new FRM paradigm:

> *It has been suggested that people with a limited knowledge of certain hazards have a tendency to trust the organisations they deem to be responsible for managing those hazards to mitigate the risks to which they are exposed (Synergist and Cvetkovich, 2000). From a flood-risk perspective, therefore, being able to trust that* ***someone*** *is maintaining the standard of sea defences or the drainage infrastructure, or that* ***someone*** *will issue warnings in time, allows individuals to perceive that they are exposing themselves to lesser personal risks (Freudenburg, 1993). It is this trust that could, in effect, be argued to have produced the perceived division of labour – i.e. the authorities use tax revenue to protect the public, which allows the public to work and pay their taxes in order to sustain the economy – that both cognitively sanctions and perpetuates the risk-taking of those who continue to make the floodplain their home. The public has a vested interest in ignoring even concerted efforts by the responsible authorities in their promotion of the need to build individual resilience to low-probability hazards; regardless of whether such aspirational policy is based on sound science*" (Deeming *et al.*, 2012: 184 – emphasis in original)

Clearly provision of information alone is not sufficient to bring about behavioural change. Re-analysis by Harries (2013) of a 2008 survey of 555 at-risk English households, for example, showed that only 39% of those who had been flooded and 6% of those who were aware of their flood risk but had not been flooded had taken steps to increase their resilience (Thurston et al, 2008). Harries (2008) as referred to in Section 5 addresses this apparently irrational lack of action from a deeper perspective that frames behaviour within the context of emotional responses. Having conducted semi-structured interviews and focus groups with 40 householders at risk of flooding, Harries concluded that the desire to feel secure can in fact prevent people from taking preventive action. He argues that perceptions or behaviours that challenge this need for security are, therefore, not always given prime importance or acted on. Steinführer et al (2009b:31) also emphasise that "a reaction of denial is not necessarily pathological and in some cases it may even help to maintain one's mental sanity." Harries (2012a) argues that policy makers ought to promote the emotional benefits of adaptation.

A further aspect of preparedness that is of increasing importance is the uptake of personal insurance. Lo (2013) conducted a telephone survey with 301 households in Brisbane, Australia, to test whether or not households were more likely to have flood insurance if

they 1) believed they were at risk of flooding, 2) could afford the costs of insurance, and 3) were subject to a social norm of buying insurance (i.e. they expected others to have it and expected they would get social approval if they had insurance). Interestingly, no statistical relationship between uptake of insurance and risk perception, experience of flood damage or perceptions of affordability was found. The only factor found to be of statistical significance was social expectation.

> *Individuals are more likely to insure themselves against flooding if they expect the same action from other people similar to them or if they expect affirmation from members of their intimate social circles, i.e. family members or friends. In contrast, apathetic or negative responses from other people may discourage voluntary adoption of insurance…social norms shape our actions for risk mitigation, such as taking out flood insurance* (Lo, 2013: 75).

As argued by Steinführer *et al*. (2009), amongst others, the information deficit model (Irwin 1995) of flood risk communication which on the one hand posits the public as ignorant and in need of educating, and on the other presumes that simply providing information and raising awareness will lead to a change in behaviour does not translate into the lived reality of people in at-risk areas. Top-down strategies of risk communication have their limitations and need to be reconsidered.

> *Our research provided evidence that adopting personal preparatory measures, being informed about public flood protection, feeling prepared and, finally, being prepared are four distinct issues each of which requires different approaches in the course of flood risk management. There is no direct, immediate, and uni-vocal link between perceptions, opinions, and attitudes on the one hand and actual actions and behaviours on the other. Although from a social-science perspective this finding is not surprising (most people know that smoking is dangerous to health but some still smoke, to provide another example), it is necessary to stress it time and again* (Steinführer *et al*., 2009: 9).

The role of expertise, collaborative learning and bringing stakeholders together

Given the variety and complexity of issues around risk perception and risk preparedness it is useful to look at approaches that aim at increasing community resilience that start beyond conventional (one way) methods of risk communication and are based on engaging communities through dialogue and discussion.

Several recent studies report on new attempts at developing strategies and methodologies for opening up flood risk management challenging the traditional positioning of flood risk 'expertise' as solely in the domain of science and scientists. These studies report attempts to harness this potential by enabling the co-production of knowledge between by scientists, key institutional stakeholders and the public. One of the reasons this is significant in terms of developing individual and community resilience is that local

knowledge can contribute to more accurate and effective mapping of, and in some instances, more economical solutions to, flood risk at the local level.

McEwen and Jones (2012) conducted research with at risk and flooded communities in Gloucestershire before and after the 2007 flood events. Their research analyses both the nature of local knowledge and how it can be captured, shared, used and institutionalised for the development of community resilience. It highlights how local people develop their own specialised knowledge of the hydrological signals of approaching floods, the causes of these floods, lag times between rain and the flooding it causes. It also reveals their expertise regarding the characteristics of floods at the local level – for example, their spatial extent, points of unanticipated flooding, water quality and local physical/human impacts (McEwen and Jones, 2012: 679). Such local knowledge, it is argued, is essential for the effective management of flood events; professional flood risk managers are more able to gain the strategic overview, but as one local authority member put it, 'resilience comes down to the local micro-detail' (McEwen and Jones, 2012: 685).

McEwen and Jones (2012:680) identify the importance of "*knowledge as doing rather than thinking*." They argue that by monitoring and assessing their own interventions, residents learn at first hand not only about the effectiveness of these interventions but also about how property protection can be improved. If the knowledge thus gained is captured and shared, they assert, this contributes to improved community resilience. However, the capturing process needs to be formalised. For example, according to one respondent quoted in the paper, although "everyone knew" that a particular care home would need evacuation if there was a certain amount of rain, this had not been written down. According to the authors, until it was formally noted and shared with others, this information was of little use to the wider flood risk management community. This suggests the need for mechanisms that facilitate the sharing of such knowledge.

Community Risk Registers as well as Community Flood Plans serve as possible routes for institutionalising local knowledge not only in relation to preparation and anticipation of floods but also to enhance resilience during an emergency. The codification of local knowledge to produce community flood plans is a way to improve community resilience.

Lane *et al*.'s (2011) paper on 'doing flood risk science differently' also has direct relevance for developing resilience within communities as it reports an experiment in Pickering, Yorkshire, in which knowledge regarding flooding was co-produced between scientists and local residents. The authors draw on Callon's (1999) work distinguishing three categories of public involvement in science – the Public Education Model, the Public Debate Model and the Co-Production of Knowledge Model – and position their experiment within the co-production model.

Within the Public Education Model, scientific knowledge is seen as the opposite of lay knowledge and is attributed objectivity and universality over and above that of public knowledge. Scientific knowledge is not contested and the public are seen as being deficient and in need of educating. In the Public Debate Model, expert knowledge retains the status it holds in the Public Education Model but stakeholders are said to require an

opportunity to comment. Within the Co-Production of Knowledge Model, "*knowledge is co-produced through a process of dynamic, collective learning involving those for whom an issue is of particular concern, whether as a result of their professional position, their personal position with respect to an issue or their personal experience of an issue"* (Lane *et al.,* 2011: 18).

The 'experiment' Lane *et al.* report on comprised, amongst other things, bi-monthly meetings between five academic scientists and eight local residents, with an open brief for discussion. This group, the Ryedale Flood Research Group met six times over a twelve month period, with intense contact between the members and academics between these meetings, including web-based discussions, one-to-one meetings with the research facilitator and participation in a reading group to discuss consultants' reports. The intended focus was the practice of science and the process of knowledge production rather than on developing solutions to flood risk in Pickering. However, the group soon began to address solutions, wanted to make its activities public and began to develop a new model for structural flood risk mitigation. The focus was on this group rather than participation with the wider community. However, as momentum within the group for working on flood risk management in Ryedale group it was decided to "go public" through and exhibition of the work of the group and this was attended by 200 people.

Amongst the many interesting aspects of this research experiment was the re-identification of 'local' knowledge from one that is purely focused on and relevant to one small area to knowledge that is universal, similar to the way scientific knowledge is traditionally thought of.

Like McEwen and Jones (2012), Lane et al found that local residents had derived from their experiences and observations knowledge of hydrology and hydraulics and had some understanding of Newtonian physics in action. The table below illustrates this by reporting on some of the ways local members talked versus the scientific language used to describe the same principles. This understanding led to the co-production of a workable hydrodynamic model for upstream storage to prevent flooding. The model that was developed where "*the burden of effort shifts from making an off-the-shelf model work in a particular place to developing model directly suited to that place*" which is now being considered by Defra. This is of particular importance given that the town was at risk of flooding (and in fact had suffered flooding in 2007, 2002, 2000 and 1999) and an EA proposed scheme (although not reaching the required cost benefit analysis) had received local resistance in 2001 leading to it being withdrawn.

Table 10: Shared concepts: modellers' and modellers'

Modellers' (local members') concepts	Modellers' (academic flood risk scientists') concepts
CG1: 'You think about a gutter and how much can go through it and if it fills up it comes over the top. So if you have got half the size of a gutter, it comes over the top more quickly….'	The principle of volume conservation for an incompressible fluid.

Modellers' (local members') concepts	Modellers' (academic flood risk scientists') concepts
CG1: 'Because of course it depends where you are, because if you are closer to the main channel, you have got something rushing really fast. But the rest of it is spreading out…it doesn't tend to be moving at great speeds, it is just sort of spreading out.'	The depth dependence of frictional resistance in river-floodplain flows. The assumption that is central to the diffusion wave approximation of the 2D shallow water equations.
CG2: 'Logic says that you have got to work out the contours and work out which is the lowest lying land. I suppose there must be some sort of formula to work out exactly the volume of water you are expecting to come down and therefore to what volume it will fill that level.'	Potential energy as a momentum source coupled to the principle of volume conservation for an incompressible fluid.
CG2: 'But Pickering is a slower process I think, than Sinnington is. And it is not such a sudden thing. I mean you can see Sinnington rising. I don't think you can here so much [because] Pickering Beck goes much further north, and it is gathering more water.'	Hydrograph attenuation.
CG2: 'The other thing that is important is that we have got heavy clay soil. But the soils vary in different parts, whereas of course the clay soil around Great Barugh means that other areas are more sandy perhaps and drain more easily.'	Infiltration and runoff generation as controlled by soil type.
CG3: 'So to protect Pickering, the nearer the dams are to Pickering the better?' [Local member 1] 'Well yes certainly' [Local member 2]	Design of flood storage schemes to remove flood wave peaks.

Source: Lane *et al.* (2011: 27)

Evers *et al.* (2012) report an attempt to use socio-technical tools to enable flood risk professionals and local residents to learn from each other about the management of flood risk and to foster a collaborative approach to risk management. They report that the use of a range of modelling approaches facilitated learning about the technical aspects of flood risk management and also the values, interests and positions of other stakeholders. The authors conclude that involving a wide variety of stakeholders in a process can provide the opportunity for each to increase their knowledge of, and personal responsibility towards, flood risk management. They also found that the participation of local champions (whether from statutory, voluntary or community sectors) was useful for building trust and

developing sustainable communication structures. The collaborative modelling process also developed alternative ways of communicating risk, leading the authors to recommend its use in future projects: "*We can confirm the findings from recent research that gathering and inclusion of "local" knowledge is essential for participatory governance in FRM. This is particularly true for the successful development and implementation of collaborative modelling methods and tools*" (Evers *et al.*, 2012: 2840).

Ashley *et al*. (2012) report on the use of Learning and Action Alliances to bring stakeholders together for capacity building and the development of collaborative flood risk management strategies. Learning and Action Alliances aim to create opportunities for participants to move away from institutional and strategic fragmentation toward relationships characterised by cooperation and collaboration. To this end, scientists, practitioners and community members are brought together:

> *The answer to fragmentation – and the start of dealing with complexity and wicked problems – is in creating a shared vision in terms of understanding the problem. Creating coherence and developing joint understanding and a shared vision is what Local Authorities (LA) in urban water aim to do. LAs should enable 'scientists' and 'practitioners' (and communities) to come together to work jointly in processes where an increasing and changing understanding of the problem leads to the emergence of potential solutions and more effective innovation* (Ashley *et al*., 2012:17).

Reporting on the early stages of a number of such Alliances in Yorkshire, Ashley *et al*. report difficulty in persuading participants to understand the how the alliances differ from other types of partnership and collective. As a result, they suggest, the alliances had so far failed to achieve their key aim of breaking through conventional norms and generating genuinely innovative approaches to flood risk management. They report that professional flood risk managers can find it difficult to adapt to this new way of working, with some feeling that the work of such alliances encroaches on their own professional responsibilities and others being reluctant to relinquish their familiar role of information providers and struggling to participate in real dialogue. The authors conclude that these problems are indicative of "*a tradition of top-down governance and incumbent regime application of regulations and funding in England and Wales*" and that this tradition is a barrier to the development of effective learning and action alliances (Ashley *et al*., 2011: 20). They also conclude that there is no single blueprint for developing such Alliances and that each place ought to adapt the model according to the needs of each locality.

Cashman (2009; 2011), too, reports on the potential benefits of bringing different stakeholders together to facilitate understanding and awareness. His evaluation of the institutional response to flooding within the city of Bradford in 2000 and 2003 points to the problems caused by the dispersal of responsibility for risk management across a multiplicity of agencies. This dispersal, he argues, served to isolate actors and create institutional barriers to cooperation at both the individual and the collective level (Cashman, 2011: 38). An interview with a local authority policy officer captures this:

> *We were going into risk management but it was about masking risk. We know these issues are out there but actually if we just turn the other way we don't quite see them and actually they are the fault of someone else. Internally we just dealt with the issues when they arose. Externally as far as we were concerned it was other people's responsibility, it wasn't about partnership workings it was about responsibility. If the water was in the river it was the EA's responsibility. If it is coming over the top it was ours and if it got into the sewers it was YW [Yorkshire Water] and when it came back out again it was ours. That was very clear and everybody saw it like that* (Cashman, 2011: 36).

Cashman reports that an enquiry set up by the local authority after the 2003 flood helped bridge the barriers to joint working by facilitating mutual learning and helping stakeholders build relationships of trust. However, although this had a positive impact on resilience and adaptive capacity in the short-term, Cashman hints that institutional isolation reasserted itself after the enquiry and that the structures put in place to ensure longer-term collaboration were not very effective.

Cashman also discusses the impact of local flood action groups that were set up by the local authority to engage people and communities with the issues and help them decide on courses of action and negotiate with appropriate agencies. This work was run by a community organisation at arms-length from the council and was overseen by a steering group of key stakeholders. Cashman (2011: 39) concludes that the action groups enhanced the sense of local community and, by allowing people to "vent their anger and seek answers", "led to a greater understanding and appreciation of flooding." These groups, too, only survived in the short-term but Cashman appears to suggest that their demise was both inevitable and, as the salience of flooding for the communities diminished, proper.

In his study in the Cumbrian market town of Appleby-in-Westmorland, Harries (2010) reports on the need for state agencies to make practical demonstrations of their respect for local knowledge and expertise. Appleby floods regularly and its residents, Harries (2010:18) says, pride themselves as being "the people who resist and survive floods." Staff from the Environment Agency and local authority did not want to undermine this local sense of resilience and self-reliance. Hence, rather than try to implement the solution that they considered technically the most advantageous, they supported local residents with the implementation of a locally designed and locally initiated solution. Local people were therefore given support for the development of a Flood Action Group and a plan for mobilising large numbers of residents to distribute sand bags in the event of a flood. Through providing this support, the agencies overcame the distrust that had previously characterised relationship with the town and were more able, at a later date, to suggest additional flood risk management measures.

Also critical to gaining trust was being able to recruit key locals who had connections and influence in the area and who were in a position to be able to influence residents to participate in the pilot.

As well as research on processes and methodologies, other research has been examining more specific issues related to creating resilience, such as property level protection and its role with insurance.

Insurance can be an aspect of resilience, a barrier to resilience or a factor promoting resilience[12]. Deeming *et al.*'s (2012) paper on recovery following the 2007 Hull floods highlighted how access to the resilience provided by insurance is sometimes restricted. The researchers quote one resident's account of her experience with her insurers following the floods.

> *We went on the web looking for insurances and… other insurance companies don't particularly want to take you on and the premiums were that high it was unbelievable. So we stuck with the same insurance company and they took us back on and the premium only went up £50 and that wasn't a problem. But the excess has gone up: £5,000 we have to pay on contents and £5,000 on buildings. So if the same thing happened again we've £10,000 to find before we start. And where do we pluck that from? Where do we get that from? We haven't got £10,000. Or do we save anything at all or do we literally just let the whole lot go and say it's all gone and claim what we can and just have everything lesser*? (Deeming *et al*., 2012: 192).

This quote illustrates how, in the present market, insurers tend to respond to a flood either by increasing a customer's premiums or increasing her excess level. While the former maintains the contribution of those who are willing and able to pay the increased premiums, it can make insurance unaffordable and will encourage some householders to opt out of flood insurance altogether. As illustrated by the above quote, on the other hand, although an increase in excess levels maintains affordability, it diminishes the usefulness of insurance for maintaining resilience.

At present (June 2013 – Feb 2014) the issue of flood insurance is under review, with the consideration of a new arrangement between UK government and the insurance industry (Defra, 2013). The preferred solution to the now-expired 'Gentlemen's Agreement' approach that has underpinned domestic flood-insurance provision since the 1960s, is a pooled reinsurance system called "Flood Re". The idea under consultation is that those in the highest risk areas would be able to access flood insurance. At the end of a period of 20-25 years insurance premiums for those households would return to a system of risk-based and risk-reflective calculation. Even if agreed, it is not the intention to implement Flood Re until 2015 however, what the Defra consultation has clarified is that for the next two years the domestic insurance market in the UK will operate much as it has for the past decade.

[12] We acknowledge that the issue of insurance is vital to flood risk resilience at the household level, but we found few papers on the topic within the review and also did not want to duplicate work being carried out under another Defra project (Flood Social Science Synthesis), so our brief discussion here is not intended to suggest that it is not an important topic.

Deeming *et al.*'s research also illustrates how insurance can deter the adoption of other resilience measures. They report the insistence by insurance companies on like-for-like restoration and how they disallowed any resilience measures (for instance, the use of more flood resilient plaster) that would constitute 'improvements'. Although this experience is not untypical, it is also possible for insurance and insurers to promote resilience. Harries (2010) reports the case of a high street shop in Cumbria whose insurer both advised on suitable adaptations and funded their implementation as part of a post-flood restoration. Harries (2010) also describes how some businesses only use their insurance to protect them against the costs of extreme floods. To avoid large increases in insurance premiums, they do not make any claims for smaller floods, choosing instead to protect themselves with other resilience measures such as flood plans and flood barriers.

It is also possible that those with effective and affordable insurance against flood losses will be less inclined to take practical adaptation measures because they know they can rely on the cover provided by their insurers. Known in the insurance literature as moral hazard, Harries (2012) found evidence of this phenomenon in his analysis of a survey of at-risk residents of England, in which respondents who agreed with the notion that insurance was a substitute for flood protection were less than half as likely to have implemented physical protection measures ($N=512$; $p < 0.05$).

As reported by Deeming *et al.* (2012), residents sometimes express doubt about spending their money on physical adaptation measures because they are unsure of their efficacy. Using evidence from interviews with at-risk residents of Reading, Harries (2012b) explains this with reference to people's desire to avoid the feelings of blame and regret that they anticipate they will feel if a measure implemented by them is later deemed ineffective or unnecessary.

There is some suggestion in the literature that people's confidence in their ability to choose and implement the right resilience measure can be a significant barrier to action. For example, Harries (2010) suggests from his research in Appleby-in-Westmorland that physical resilience measures are more likely amongst those who possess salient professional skills or have access to friends or neighbours with such skills. On the other hand, although Harries' 2013 survey analysis found that 27% of at-risk householders agreed with the statement, "I don't think I'd be able to choose the right way to protect my home", this was not significantly associated with the implementation of protection.

Harries (2010) argues that support with choosing resilience measures is key to the enabling householders to feel responsible with respect to flood risk. Citing the statistical analysis (Harries, 2011) that indicates the absence of any link between the perceived cost of measures and their implementation ($n=519$, $p=0.12$), he argues that confidence is a more important factor. Harries' (2010) research with beneficiaries of government-funded property level protection suggests that the funding was important not because the measures would otherwise have been unaffordable, but, rather, because they gave the necessary "stamp of approval" to the type of measure that was implemented and because the scheme made it simple and easy for residents to choose and implement flood barriers.

7. How is Resilience Measured? What Metrics Exist For Measuring Resilience?

Introduction

The review process identified a range of academic literature that specifically addressed the issue of measurement in relation to community resilience and social vulnerability to natural hazards such as flooding. The object and subject of measurement vary considerably. In many earlier studies measurement of social vulnerability indices (SoVI) indicates levels of social vulnerability with a view to developing policies and practices for vulnerability reduction improvements and resilience enhancement. Other studies have focused on the strengths and weaknesses of plans, policies and actions, or in calculating the cost-effectiveness of mitigation activities through quantified cost-benefit analyses. A number of studies have begun to develop more detailed and in-depth qualitative indicators in order to try and capture or 'characterise' the ideally resilient community. However, in all studies there is recognition of the complexity of the social and economic factors, the problems associated with defining both resilience and community, the difficulty of evaluating the changing dimensions of community resilience over time and the huge challenge of developing useable indicators to map these dimensions in a coherent manner.

Measuring social vulnerability

Nonetheless, the measurement, or indication, of community resilience is desirable in helping to develop effective interventions, practices and policies for FRM and to build resilient communities. Cutter *et al.* (2013) point out that it is essential to develop methods and indicators to measure the conditions influencing disaster resilience in order to establish a set of 'baseline conditions' from which work. They say that it would be impossible to identify changes in a community resilient to disaster without measurable baseline conditions and they have focused on 'social vulnerability' to explain why some communities experience a hazard differently. The authors developed and used a Social Vulnerability Index (SoVI), based on a well-known method of identifying social impacts. It is an algorithm that has been developed using a statistical method and can be combined with traditional cost-benefit analysis to produce a context-based result. The term social vulnerability is used broadly to include both social and economic factors. This study argues that an understanding of the differential impacts of hazards such as flooding, as a product of social vulnerability, is a crucial element in formulating more effective FRM.

An important aspect of FRM is emergency planning. The improvement of community preparedness capacities has become more significant in the move towards enhancing community resilience and Lumbroso *et al.* (2011) have described the process of developing a series of metrics to measure the effectiveness of the emergency planning procedures. The authors noted that, although there would always be an element of subjectivity in them, the metrics provide a basis and a map from which to consult stakeholders and make improvements on a transparent and ongoing basis.

Other methods of modelling social vulnerability (see Zahran, 2008) have used deductive quantitative modelling techniques to link geographical localities that are characterised by a

high percentage of vulnerable communities with higher than expected casualties due to flood events. However, according to Yoon (2012), who compared a range of ways of assessing social vulnerability, including both inductive and deductive methods, it is important to note that different methods can often produce different results.

Indicator	Type/composition of the indicator.	Indicator categories/variables
Social Vulnerability Index (SoVI) Cutter, S *et al*., 2013	SoVI synthesises a variety of socioeconomic variables derived primarily from census data.	Socioeconomic status; Gender, Race and ethnicity; Age, Employment; Rural/urban; Residential property; Renters; Occupation; Family structure; Education, Medical services; Social dependence; Special needs populations.
Disaster Resilience Cutter, S. et al 2010	Described by a set of baseline characteristics (composite indicators) of communities that foster disaster resilience..	Social, Economic, Institutional, Infrastructural, and Community components
Coastal Flood Vulnerability (CCFVI) Balica, S. *et al.*, 2012	The Coastal City Flood Vulnerability Index (CCFVI) is specifically used for coastal flooding	The CCFI calculates exposure, susceptibility and resilience to coastal flooding. The system's components are, hydro-geological, socio-economic and politico-administrative.
Community Resilience Index (CRI) Ewing, L. and Synolakis, C., 2011	The CRI has been developed in relation to coastal flooding and is described as "bare bones"	The CRI has measures of Local Susceptibility to hazards Community elements exposed Availability of safe Substitute/Redundant Services Recovery Time

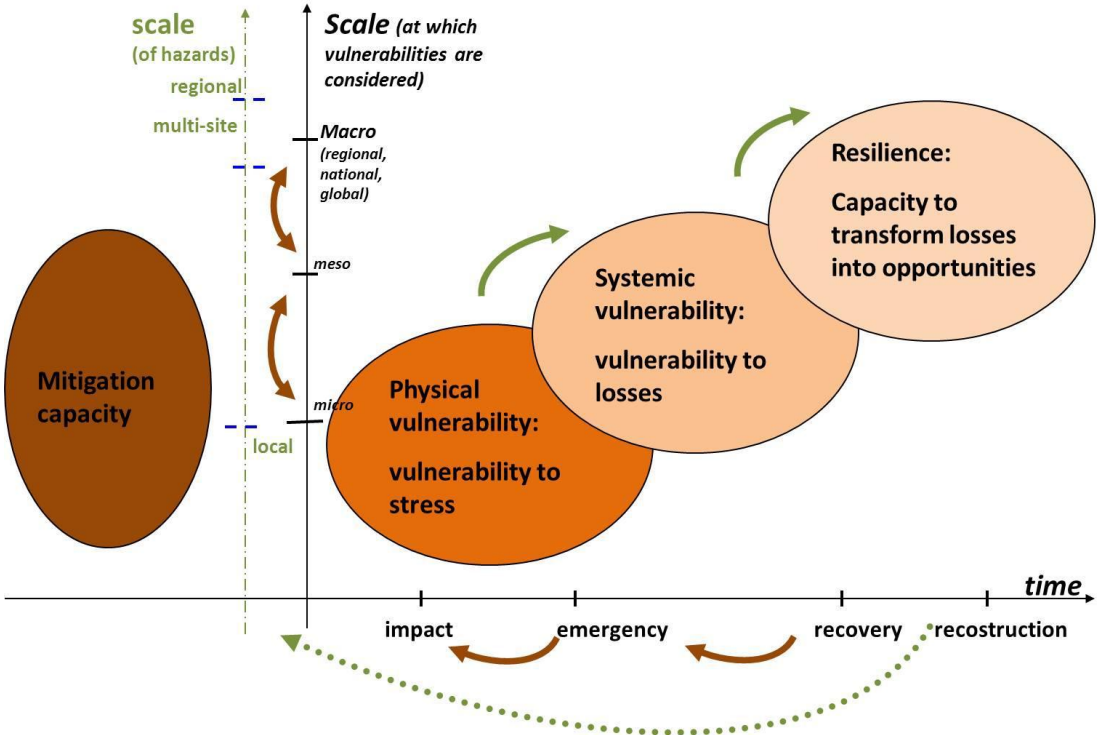
The relationship between vulnerability and resilience

There is now more focus on measurement and fostering of community resilience, rather than monitoring social vulnerability. A traditional view of seeing resilience simply as the reciprocal or 'flip side' of vulnerability (i.e. that a decrease in vulnerability is matched by a corresponding increase in resilience), is challenged as discussed in Section 5, because where vulnerability can be viewed as the static property of a system (or community) resilience captures a more dynamic idea of capacity to adapt to upheaval and change. The ENSURE project presents a 'Vulnerability and resilience framework tool' (Figure 7) that indicates the relationship between vulnerability and resilience but also brings together the time and space dimensions of a flood hazard cycle. The figure suggests the different foci for measurement in terms of vulnerability and resilience at different points in the disaster cycle, and at different scales. The x-axis shows time through the disaster cycle, with arrows to indicate that the way each stage is managed feeds into how the next emergency is managed, and that reconstruction merges into mitigation. In terms of the y-axis this is a measure of scale from the local to the national scale. From their research, the authors suggest:

> *At the impact, instead, the physical vulnerabilities play the major role: the direct physical damage that can be accounted for are strongly correlated on the one hand to the severity of the hazard, on the other to the level of physical fragility of artefacts and constructions. As the time from the impact passes, other forms of vulnerability gain relevance and, in particular during the emergency phase, precisely systemic vulnerabilities. Those express the response capacity (or lack of) not to the direct extreme event impact but rather the consequences of the latter, to the impairment in crucial systems and their components provoked by the physical damage. Finally, considering the time of reconstruction and recovery, resilience gain prominence: here again the response is not to the stress, but to the longer term induced, indirect, secondary effects it has produced. What we want to measure here is not merely a response capacity, but rather whether or not systems is able to recover by reducing pre-event vulnerabilities, to learn from the weaknesses that the event has revealed and to transform reconstruction into an opportunity to build and develop a better, safer and healthier place to live* (ENSURE, 2011: 20).

The policy benefits of facilitating resilient communities have been noted along with the requirement to evaluate progress in building resilience.

Figure 7: General representation of an integrated framework to assess vulnerability and resilience across time and scales



Source: ENSURE, 2011

Quality or quantity?

The dilemma faced, in identifying a common set of preferably quantifiable indicators against the more complex socio-economic variables inherent in the evaluation of resilience in communities, has resulted in the majority of studies using a range of both quantitative and qualitative methods. Nonetheless, as Djordjevic *et al.* (2011) argue, there are compelling reasons for quantifying the cost-effectiveness of resilience measures and FRM plans since this is the most direct way to inform more universal and scientifically sound policies and plans.

However, in order to overcome the limitations of traditional project by project cost-benefit analysis Godschalk *et al.* (2009) emphasise the need to build up a broad range of evidence from numerous case studies to provide richness and scope and to combine this with a quantified cost-benefit analysis for scientific objectivity. They believe that well documented insights from such evidence can weigh positively in support of quantified analysis. Hazard mitigation planning is given as an example of how the uncertain science of forecasting can be enhanced with a rich data set based on a large body of research from case studies to provide overwhelming evidence for the value of pre-planning, or foresight actions, in preparing for hazards such as flooding (i.e. 'an ounce of preparation is worth a pound of cure'). This approach was funded, in the US, by the Federal Emergency Management Agency (FEMA) and conducted by the Multi-Hazard Mitigation Council (MMC) to evaluate possible savings from mitigation activities.

Capturing community resilience

It is generally agreed that the concept of community resilience is difficult to assess and 'operationalize', not least because it is such an ambiguous concept that different disciplines have different ways of characterising. A research team working to understand and build resilience to disasters in Europe (emBRACE) have reviewed several different schools of thought (emBRACE, 2012a). The researchers aim was to bring together several different perspectives on resilience. This included Cutter's (2010) characterisation of the multi-faceted nature of resilience as a combination of: social (e.g. age, transportation access, telephone access, language competency), economic (e.g. housing capital, employment, income and equality, health access), institutional (e.g. mitigation, insurance, experience), infrastructural (housing type, shelter capacity, medical capacity, evacuation potential'), ecological, and community (place attachment, political engagement, social capital, religion, civic involvement, advocacy) elements and indicators which we have referred to through this review.

Equally, the emBRACE review found that the concept of community is neither well understood by the literature nor coherent as discussed earlier in Section 5. Also, although with the exception of identity, the communities identified by emBRACE correlate with those defined by the Cabinet Office (Cabinet Office, 2011), it could be suggested that one of the most important 'communities' in terms of resilience building has been missed from this typology. Wenger (2002) suggests that individuals who jointly pursue a particular competence should be defined as members of a community of practice. To illustrate this point, consider a group of professional 'resilience practitioners' (supporters), who work closely alongside a hazard-affected community (circumstance) with a common aim of increasing their resilience to future hazards. If this joint aspiration is pursued with a sense of mutuality and through the adoption of a shared repertoire of communal resources (e.g. language – 'risk', 'return period') then, according to Wenger, this makes for a community of practice. Pelling *et al.* (2008), however, argue that the effectiveness of such communities is often an implicit function of interactions between members that occur within a 'shadow system' (e.g. a candid discussion beside the coffee machine), rather than through the success of formally employed 'participatory methods'.

The measurement of community resilience is, therefore, challenging for a number of reasons, not least a lack of reliable tools and assessment methods to capture the relevant aspects of the ways in which communities interact and change. In a study by Steiner and Markantoni (2013) research was based on the 'Capacity for Change' (C4C) LEADER programme in Dumfries Scotland through community engagement and empowerment. This approach to community resilience sought to enhance the capacity of rural places and to develop inclusive communities. Steiner and Markantoni developed an evaluation model to explore the scales and levels of resilience at individual and community level (see Figure 8 below). They used this matrix in asking a number of exploratory questions. The answers were rated 1 -10.

Figure 8: Components of resilience in communities

Source: Steiner and Markantoni, 2013: 5

A significant contribution of this study is that the proposed model enables the measurement of resilience in qualitative and quantitative ways which, if applied in a longitudinal study, could compare different dimensions of resilience between communities over time. These characteristics are currently sought among policymakers (who want to build stronger and more resilient communities and need to assess their policies), funders (who want to find out how efficient their spending and value for money are) and practitioners (who want to positively influence the life of communities). The research, based on findings from 155 face-to-face interviews in Scotland, found that where communities had begun to establish diversified services and more complex inter-relationships they reported increased resilience.

The focus on community resilience continues to develop with the realisation that many communities, particularly in coastal regions, are becoming more susceptible to climate change and less well able to rely on unsustainable and non-resilient approaches to community development. In a paper based on US case studies Ewing and Synolakis (2011) outline their development and use of a Community Resilience Index (CRI) based on lessons learned from recent storms and coastal flooding. Their principle argument is that: “a community resilience index can help communities recognize their resilience, strengths and opportunities for improvement” (Ewing and Synolakis, 2011: 1).

Developing indicators

Several recent studies have begun to develop indicators in an attempt to bring together the results of their own and other’s research studies into a systematic set of conditions to identify the features of community resilience. A report, based on reviews of such studies, was carried out for the emBRACE project (emBRACE, 2012b). The report refers to work carried out by Cutter (2010) and a report for the UK Department for International Development (DFID) by Twigg (2009). The DFID project set out to develop key indicators – or characteristics of a disaster-resilient community – in order to support monitoring and evaluation of locally funded overseas development projects. The research was published at a stage where it could offer a comprehensive multi-hazard/multi-context set of characteristics. Whilst the researchers acknowledge that these characteristics of a resilient community could be described as ‘utopia’ they suggest that it is their task, as a group of

agencies, to pilot those characteristics that are particularly relevant to their work - possibly to further refine and narrow the volume, or maybe just to critique the current content. Either way the characteristics are described as ‘a work in progress’ and they qualify the results of their guidance in the following way:

Communities and their partners therefore need to make their own judgements about whether or not certain aspects of resilience have been achieved. Some of these will be more straightforward than others. For instance, it is easy to tell if a community disaster preparedness or contingency plan exists (even if its quality is another matter). But it is much harder to decide if there is an equitable distribution of wealth and livelihood assets in a community, or the adequacy of access to common property resources that can support coping strategies during crises. (Twigg, 2009:57)

The emBRACE project developed a system that grouped all studies under consideration, through a descriptive approach, according to the source of disturbance (i.e. hazard), dimension, scale, phases/context, component, indicator and measurement of resilience. The report observed a strong desire, in published studies across many disciplines, to understand and evaluate the essential components of resilience. But, they acknowledge that there has been quite a significant discrepancy in the outcomes, often with different studies using different indicators to measure the same components, or characteristics, of resilience.

An interesting finding was that non-academic reports were well ahead of the peer-reviewed literature in proposing frameworks to measure community resilience. Academic studies, on the other hand, were better represented in research to measure organisational and institutional resilience. A further striking feature of most of the approaches reviewed for this study was the lack of information on measurements with only very few of the studies under review presenting information on how to quantitatively measure the indicators of resilience that they identified. This suggests that measuring resilience in a traditional way, by presenting quantitative data, presents a fundamental challenge to most researchers, as most of the indicators proposed to measure resilience are not operationalised. The researchers point out that: whether or not measuring resilience is a challenge that can and should be overcome depends heavily on the underlying conceptualization of the concept (emBRACE, 2012b).

In other studies reviewed for this section there were similar observations about the challenges of developing useful indicators of social vulnerability and community resilience. For instance, research reported by Kuhlicke (2011), presents findings from social vulnerability assessments conducted in different case studies of flood events in Europe (Germany, Italy and the UK). The case studies relied upon a common set of comparable indicators. The researchers commend the use of generalisable indicators for their role in putting the ‘issue of natural hazards and social vulnerability into the heart of Government thinking’ (Kuhlicke, 2011: 791) but they caution that, where indicators rely exclusively on statistical data and the use of quantitative modelling, it is difficult to fully understand the context. So, they do not refute the value of indicators if they are developed with a ‘context-sensitive’ understanding of social vulnerability at a local level. Further limitations include the need to be aware that the local context would be evaluated at a specific moment in time, rather than assessing people’s vulnerability and resilience throughout the many phases of a disaster cycle. A shared finding across the case studies was that it was not possible to identify a common set of socio-economic–demographic indicators to explain social vulnerability for all phases of the hazardous events.

The ENSURE project has also discovered the need for 'more conceptually informed vulnerability indicators or parameters and more satisfactory operational tools to assess weaknesses and resilience in coping with natural risks. (see, for instance, ENSURE, 2011; and Menoni *et al.*, 2012). Furthermore, understanding the complex dimensions of social vulnerability and resilience is seen as an essential means of explaining why different communities experience the same hazard differently. In the paper by Menoni *et al.* (2012) both the framework tool and its application to Sondrio in Italy, which is exposed to flash floods, are presented and discussed. This methodology comprises two key elements: firstly a general theoretical framework, which identifies and articulates four principal components of hazard vulnerability and resilience, as defined in the ENSURE project within time and space dimensions; and secondly, a vulnerability and resilience assessment framework tool comprising four matrices based upon the theoretical framework. The theoretical framework and matrices are multi-faceted and the tool also brings together different aspects of vulnerability, including exposure and resilience, within a framework. This tool is 'prevention oriented' in order to inform assessments of the strengths and weaknesses of current mitigation policies and actions which, as Menoni argues, will lead on to recommendations for vulnerability reduction improvements and resilience enhancement (Menoni *et al.*, 2012: 2078).

Evaluation of indicators

It is generally agreed that it is essential to work towards a common set of comparable indicators in order to bring about improvements, and this task is not without challenges. One of those challenges for Kuhlicke *et al.* (2011), and others, is the understanding that not all indicators have equal weighting and therefore evaluation of the indicators should be considered as a central issue. In this case there is a suggestion that this could be carried out by local residents and stakeholders – bringing it back to the local context. In particular, the notion of local involvement in evaluating indicators reflects the widespread belief, in the literature, that community resilience will not be enhanced unless local people take ownership of the issues because, as the DFID report suggests, no amount of research can:

> *Tell projects and communities how they should reach these judgements. They are matters for collective agreement between the stakeholders. The conclusions will be different in each case, according to context and expectations, and there will be a fair amount of subjective judgement. But in every case the process for reaching decisions must be transparent and participatory* (Twigg, 2009: 57).

Haarld *et al.* (2012: 20) drawing on the work of Cutter makes the point that different communities will require different types of analysis and interventions as they have different resilience needs. They develop a model that could be used to help evaluate resilience in different areas concluding:

> *This paper has attempted to make the case that models and measures are needed that will provide the ability to predict and compare the resiliency of areas that are as disparate as Fisher Island, Talbot County, and Hampton Roads. In particular, output and outcome measures that will enable the evaluation of effectiveness of inputs and activities are needed. Although there are common elements that determine vulnerability and resilience, local factors may indicate very different strategies.*

8. Discussion and Conclusions

In this final section we draw out the key issues from the review, evidence and data issues and finally suggest what might be useful in the context of the Defra Flood Resilience Community Pathfinders.

Resilience: definition, practice and measurement

As shown by the discussions in Section 5 there is considerable research around defining resilience, much of it located within the wider context of disasters and climate change rather than specifically relating to flood risk management. It is interesting to note that the use of the concept of resilience in relation to flood risk management in the UK is relatively recent with a relatively narrow definition appearing in the Making Space for Water strategy document (Defra, 2004), focussed on resistance and resilience of buildings. It is in the Pitt Review (2007) post 2007 floods that the term becomes used more widely, in relation to "critical infrastructure" and also "personal and community resilience". The fact that the most recent Environment Agency (EA) Flood Risk and Coastal Erosion Risk Management Strategy (EA, 2011) has the title "Understanding the risks, empowering communities, building resilience" shows the extent to which the language of resilience has been embedded into flood risk management rhetoric and policy development. Likewise within, it is useful to bear in mind comments from the emBRACE (2012a: 1) project that "Resilience as a contemporary concept brings together in varied ways and with different priority, sets of empirical concepts that have long been the focus of social analysis."

What does seem clear is that the way resilience is framed will lead to different actions and emphases. For example, resilience conceived as only resistance and applied to structural aspects of flood risk management will lead actions to focus on increased flood defences which in turn may become unsustainable and may encourage people into a false sense of safety. The focus on structures and resilience as resistance has been shown to be unsustainable given the predicted increase in floods and rainfall in the context of climate change. Floods are predicted to be not only more frequent but also more unpredictable (Defra, 2012b) and call for strategies and actions that can cope with uncertainty and are not only robust but also adaptable. It is likely that places that regularly get flooded will get flooded more frequently but at the same time surface water floods may become something we all have to get used to.

Secondly, the evidence shows that flood become a hazard with negative impacts because of the inextricable link between the physical processes and the social systems. The case examples presented through this review show how all aspects of the flood risk management cycle from planning through to recovery are dependent on the physical and social systems. For example, the impacts of Hurricane Katrina in New Orleans were a combination of the underlying vulnerabilities of people in the communities, together with mismanagement of the emergency response, in tandem with inadequate structures (the levees) and a hurricane that was one of five worst in the history of the USA.

Given this, definitions of resilience to guide policy and practice need to be able to be sufficiently nuanced so as to incorporate this complexity and to help provide practical ways through it. The model that comes from DFID presented in Section 5 provides a useful overview and summary of the resilience definitions examined. To this we draw out the

aspects highlighted by the evidence (e.g. ENSURE, 2009) with respect to core dimensions of **robustness, adaptability and transformability** together with the different domains/capacities of resilience after Cutter *et al.* (2010) (**social, economic, institutional, infrastructure, and community capital**). These dimensions and the domains can both be existing properties of the system (e.g. a town may have good social networks) and drawn upon within the emergency becoming part of the adaptive capacity as well as characteristics that may emerge during and after the flood (e.g. flood action group) taking Cutter *et al.*'s (2008) concept of emergent resilience.

But is all this grounded in real data? And can we predict from these models what will make a place resilient to flooding or not? Certainly the papers discuss in Section 5 are grounded in real examples and we have highlighted some of those examples. However these models/frameworks are largely at the descriptive stage, they describe data and experiences, mainly from after disasters or floods have happened and for good practice to be drawn out but rigorous testing of hypotheses as to how the dimensions might work in practice and whether one is more important than another in terms of building resilience has not yet been carried out.

Much of the interesting resilience thinking is being developed in the context of disasters in general on the one hand and adaptation to climate change on the other hand, rather than in relation to flood risk in particular which is a further reason why these definitions and theories need more testing.

What can be said then about resilience at different levels of analysis? Overall, the evidence is still rather a patchwork of findings, many of which are not framed within a resilience approach yet clearly are central to understanding and developing resilience. For example, at the individual level social vulnerability is an important focus with much existing work already, helping to understand the pre-existing vulnerabilities as well as flood related vulnerabilities. As noted in the review we see vulnerability and resilience as related but not the opposite of each other, a person can be vulnerable but also resilient in a flood emergency.

It is important that in taking a resilience framing of flood risk management policy and practice does not ignore underlying issues of power, inequality and deprivation that have been usefully researched within research into vulnerability, especially in the developing world. Care is needed that by taking a systems view of resilience that has largely emerged through the natural sciences (engineering, ecosystems), that the reflexive nature of social systems and critical social science perspectives are not lost.

Activities to build resilience need to consider how they interact with vulnerabilities such that they help to reduce those vulnerabilities where possible.

Work on individual risk perception/awareness/actions in relation to flood risk has a considerable amount of evidence and it can be fitted into the characteristics approach of Cutter, risk perception/risk actions are all part of building "institutional" resilience whilst PLP and other physical measures are part of building infrastructure resilience. Flood action groups both build community capital and institutional resilience. At this individual level the evidence shows us that the relationship between awareness and action before during and after a flood is complex. "Although the experience of a previous flood makes residents somewhat more risk aware, there is no simple equivalence between awareness and preparedness" (De Marchi *et al.*, 2009). Harries' work provides valuable insights into the social psychological aspects relating to property level protection uptake and useful situates PLP within a wider context.

In relation to the community level there is evidence around the relationship between the nature of the community and types of resilience, with the suggestion of the central importance of networks both close ties and looser links between members of communities and more formal organisations. Links between people enable links to resources which can be drawn upon during floods. Bringing people together to draw on local knowledge and to empower people to help solve flood risk management issues is at the centre of the work by Lane (2011) and McEwen and Jones (2012). From these pieces of research it would suggest that learning about flood risk and co-creating solutions to flood problems in trusted, ongoing relationships between community members and professionals is a really fruitful area for development and further practice.

From the discussion of issues around societal resilience it is clear that consideration of the resilience of governance structures for flood risk management is also needed: taking a socio-technical systems approach means that the concepts of robustness, adaptability, and transformability need examining at the individual, community and societal levels. Consideration of how these play out in practice would be useful for further research. Ashley *et al.*'s (2012) work reported in Section 6 highlights the need for flexibility specifically within organisations to support learning alliances but the broader principle is that organisations will need to consider how far they can operate within a system that accepts uncertainty and the need to adapt and change with circumstances.

How then can this be measured? The review of measurement in Section 7 shows that getting to grips with definitions of resilience is a key starting point to be able to measure resilience. The importance of baseline data is also highlighted together with caution attached to over generalisation of findings and the need to understand each situation as a constellation of resilience factors that come together in ways that are unique to each situation. Work on indicators and qualitative measures of resilience using agreed definitions is in its infancy.

Areas not covered in the review

As is discussed in the section on the REA process, the database searches carried out focussed on flood resilience and that was what we asked our experts to provide us evidence with. Resilience in the context of flood risk management is a relatively new (last five years) and is spread through a number of disciplines which may mean that other work on flooding e.g. social impacts of flooding would not be picked up through our search. We have given a flavour of some of those issues in Section 5 but further work could bring together other flood research within a resilience framework.

The review touches on issues around insurance as it was in scope to begin with in the review. However, there were very few papers on insurance and its impact on other resilient behaviours, why people do/don't take out insurance etc. Further, the Defra Flood Social Science Synthesis project took insurance issues as one of its topics and that project combined research with workshops therefore enabling some of the key questions to be teased out. From what we have reviewed in relation to insurance we would suggest that more work is needed to unpack exactly what are the key policy questions in relation to resilience as well as the social research questions.

The review did not look at economic resilience in relation to flood risk management. The main reason for this is that there was little evidence found through the database search and only a few papers from our experts. We would suggest that economic resilience at the

individual, community and societal level is a topic that warrants its own focus and research and there was not time within this review to carry that out. It is clear that the role of small businesses in communities is crucial to the longer term resilience of those communities but there is little research looking at what builds resilience to flooding more generally in relation to businesses of all sizes. In relation to businesses there may well be work within the business continuity body of literature that is relevant

A further aspect to highlight is that the evidence reviewed has centred on preparedness and incident management with much less emphasis on planning and recovery. Whittle et al.'s (2010) work on recovery from the Hull floods vividly highlighted the length of time, social, psychological and physical work that is needed for recovery, and stress the negative impacts of "dealing with the clean-up." Understanding the factors that enable resilience to those impacts is something that would be useful to follow up on in further work.

Issues of data, interventions and evaluation

One of the key findings in this area is the lack of formal evaluation of "interventions". Two issues in this, firstly there is a lack of evidence around policies, and practical actions that have been intentionally carried out with a specific view to improving resilience in relation to flood risk management. Secondly, where there have been those interventions, they have not been formally evaluated.

Interventions such as there are, tend to be qualitative, "real-world", rather than in the random controlled trial model of research. Certainly the standards of random controlled trials (RCTs) etc. which are held up as the gold standard for systematic reviews and REAs are not present within this body of evidence. This is for several good reasons: firstly, flood risk resilience is an applied, complex area with multiple actors and variables which means that first establishing causal relationships e.g. between increased awareness and change in individual actions is not straightforward making the study of them also not unproblematic.

Secondly, flood risk resilience is an emerging, interdisciplinary area of study as discussed earlier and as such has not moved into a more hypothesis testing phase of work although in some areas there is that tradition (e.g. attitude-behaviour research) which could be drawn on.

Finally, related to the point above, flood risk resilience by its nature because it is dealing with complex socio-technical systems requires a range of disciplines and indeed as this review has shown the papers are distributed over a wide range of disciplines, each with specific perspectives and emphases with respect to methods, robustness of data and hypothesis testing. We suggest that this needs to be fully discussed in relation to REA methods to understand how quality can be assessed across disciplines so that robust studies are used for evidence reviews.

Relevance to the FRCP

The review here has highlighted the need to understand resilience as complex and multi-faceted. For the Pathfinders it will be important for us to try to pinpoint which aspects of resilience they are targeting with their interventions and to develop measures to assess

their effectiveness. The measurement review suggests that there are not ready made quantitative indicators that could be used but that it is important to try to gather some quantitative baseline data. This is one aspect of the evaluation. However, given the contextual nature of resilience it is clear that qualitative data is also needed.

In terms of the information on dimensions i.e. robustness, adaptability and transformation and understanding current concepts of resilience we suggest through the evaluation it may be possible to uncover and reflect on how definitions of resilience are manifest in practice and the implications of those definitions.

In terms of useful aspects with respect to interventions, the review reinforces the complexity of the relationships between awareness and action, both being important aspects of resilience but not having a linear relationship between them. Interventions based on community engagement, dialogue and learning seem to provide most promise in terms of improving resilience to flood risk at the community level.

Finally, it is vital to highlight that community resilience is only one aspect of the socio-technical system that is flood risk management. Developments in spatial planning, land management, flood defences, sustainable water management are other vital aspects of the system. It will be important ensure that findings from the Pathfinders are situated alongside other developments towards flood risk resilience in the UK.

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Appendix 1: Data Extraction Form and Quality Criteria

Citation Details	
Author(s)	
Year of publication	
Title of paper	
Title of publication(e.g. book, journal, report)	
Vol., Issue, Pages	
Reference number	
Nature of Study	
Location	
Date	
Purpose of study / aims	
Resilience category	
Methodology (quantitative, qualitative, mixed)	
Research design (what they did)	
Intervention tested, if any	
No. of participants	
Target population (e.g. vulnerable groups, ethnic minority)	
Main findings	
Summary of conclusions	

Quality Assessment			
	Yes	**No**	**Not applicable/sure**
1. Was there a clear statement of the aims of the research? Was it related to the REA questions?			
Methodology			
2. Was the methodology chosen appropriate?			
Research design			
3. Was the research design appropriate to address the aims of the research? Is there a discussion of the choice of			

research design?			
Sampling			
4. Was the recruitment strategy appropriate to the aims of the research? If representative sampling was used, was the sampling frame (selection of participants) representative of the population being studied?			
Data collection			
5. Were the data collected in a way that addressed the research issue? Were the methods chosen clear and were they justified?			
6. If there was a comparison or control group, were they similar enough to the intervention group to be comparable?			
7. If qualitative research design, has the relationship between researcher and participants been adequately considered?			
Ethics			
8. Have ethical issues been taken into consideration? Whether consent was obtained from participants and information sheets provided.			
Data analysis			
9. Was the data analysis sufficiently rigorous? Was it sufficiently described and an appropriate sample analysed? For a quantitative analysis, are enough data presented for results to be valid and useful (i.e. on both the dependent and independent variables).			
10. Is there a clear statement of findings? Whether the studies gave enough depth and detail to give confidence in their findings. Whether the studies assessed the relevance of their findings to the wider population and/or context.			

Appendix 2: Summary Table – Section 5

This table summarises the core papers used in Section 5 – other papers are referred to in the document but did not form the core of the review for this section and so are not listed below.

Author/Date	Type of paper	What is being reported?	Database (D) or expert (E)
Andrew 2012	Journal Article	A review of community resilience in practice looking at past cases in the UK	D
Bahadur *et al.*, 2010	Review for UK Government DFID	A review of approaches to resilience in the context of disasters	E
Burningham, Fielding and Thrush (2008)	Journal article	Study on flood risk awareness in UK	E
Cabinet Office, 2011	UK Government Framework	The framework is intended to provide the UK national statement for how individual and community resilience can work.	E
Coates (2010a)	PhD thesis	A examination of the role of community structures and their different effects on flood risk management practices – with case studies from locations in the UK	E
Cox (2012)	Journal article	Discussion of how using an individual decision theory approach to risk analysis may not be effective for catastrophic events given their unpredictability and uncertainty and suggests taking a community perspective focussing on networks and relationships	D
Cutter *et al.*, 2010	Journal article	Develops an approach to measuring resilience to disasters	D/E
Cutter, 2008	Journal article	Development of disaster resilience of place model	D
Cutter, Boruff and Shirley, 2003	Journal article	Understanding social and place vulnerability in relation to disasters	E
Davoudi *et al.* 2012	Journal article	Examination of GLA draft climate change strategy using a resilience framework	D
DFID, 2011	UK Government Department paper	Defines resilience in relation to disasters	D
emBRACE,	EU FP7 project	Two reports from the ongoing emBRACE project one on defining resilience and the	E

Author/Date	Type of paper	What is being reported?	Database (D) or expert (E)
2012a, 2012b	report	other on measurement issues	
ENSURE, 2009a	EU FP7 project report	Examines vulnerabilities and resilience in the context of disasters.	E
ENSURE 2009b	EU FP7 report	Focus on methods for assessing vulnerabilities of structural, territorial and economic systems	E
ENSURE 2011	EU FP7 report	A methodological framework to assess vulnerability and resilience across different temporal and spatial scales.	E
Harries, 2008	Journal article	Analysis of issues of psychological security and property level protection	D/E
Harries 2010	Research report for Defra	Review of the pilot flood protection grant scheme in one area - Appelby	D/E
Keogh *et al.* 2011	Journal article	The study aimed to gain an understanding of the vulnerability, resilience and adaptive capacity of this community by studying the 2008 flood event.	D
Kuhlicke, 2013	Journal article	Analysis of narratives of resilience in an in depth study of a flood in Saxony, Germany	D
Liao, 2012	Journal article	An approach with case study of how resilience might be measures in the urban context using the concept of floodability.	D
Neal *et al.* 2011	Journal article	Examines emergent groups, networks and activities in the Hull flood 2007 and their contribution to community resilience	D
Norris *et al.*, 2008	Journal article	An approach to conceptualising community resilience brings in idea of resources and capacities.	D/E
Pitt, 2007	Official review paper for UK Government	Independent review of what happened in the 2007 floods. Took evidence from a wide range of sources and perspectives	E
Pomeroy 2011	Report to NZ government department	Rural community resilience to climate change in NZ. Case studies and interviews, national and specific	E
Public Health England, 2011	Report by UK Health Agency	Analysis of the evidence on health impacts from flooding	E
Schelfaut *et al.*, 2011	Journal article	Reports on how increasing flood resilience can reduce flood damage. From the FREEMAN EU project – case studies in Europe	D
Sims *et al.*, 2009	Journal article	Reporting on the impact of flooding on	E

Author/Date	Type of paper	What is being reported?	Database (D) or expert (E)
		carers and the concept of home using data from flood in Hull 2007	
Smith *et al.*, 2011	Journal article	Analysis of community resilience in rural NZ in the context of flood recovery	D
Tapsell *et al.*, 2002	Journal article	Seminal paper on the social flood vulnerability index and health impacts of flooding.	E
Twigger-Ross and Orr, 2012	Report to UK government	A review of social vulnerability to climate change as part of the Climate Change Risk Assessment (Defra 2012b)	E
Twigger-Ross *et al.*, 2011	Report for DSTL and UK Cabinet Office	A review and four UK case studies relating to community resilience in emergencies	E
Twigger-Ross, 2012	Report for UK Foresight	A review of the impact of environmental change on identity in the next 10 years	E
Walker and Burningham 2011	Journal article	A review of vulnerability and inequalities in relation to flooding in the UK drawing on a number of empirical studies examining the relationship between places at risk of flooding and deprivation	E
Wardekker *et al.*, 2010	Journal article	Operationalise resilience characteristics in the context of understanding resilience to climate change in Rotterdam, NL.	E
Whittle *et al.*, 2010	Final report for EPSRC/ESRC project	Findings from the real-time recovery project looking at the floods in Hull 2007. Data collected over 18 months via diaries and focus groups. One of the few longitudinal studies on flooding	E

Appendix 3: Summary Table – Section 6

Summary of papers reviewed in Section 6. Whilst there are a couple of other papers referred to they were not core to the Section and so are not included in this summary table.

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
Preparation	**Institutional**	Understanding barriers in flood risk communication strategies	Surveys with over 1100 participants Focus groups	Results indicate that the **information deficit model for flood communications that relies on the provision of more and better information to mitigate risk in flood-prone areas is insufficient**, and that **the communications process is very much multi-dimensional**. Results also suggest that flood information in the project countries is disseminated within a hierarchical framework from national bodies, through local authorities and emergency services to the public at risk. The **linear nature of such top-down structures offers little opportunity for engagement of end users** and is not conducive to developing constructive feedback channels.	O'Sullivan *et al.* (2012)	Finland, Ireland, Italy and Scotland
Preparation	**Institutional**	Public risk perception	13 case studies comprising of a questionnaire survey (n=1375) with Individuals who are at risk of pluvial, fluvial and coastal flood risks (over half had been previously flooded)	Overwhelming majority were aware of risk but case study work in Ireland showed that those who were not aware of risk even though they had been previously flooded lived close to new structural flood defences and believed themselves to be immune from future flood risks. Highlighting **low levels of understanding of the probabilistic terminologies** and a disconnect between the language used by the engineering community and that understood by the public at large. Found no correlation between awareness and action taken towards preparedness so suggest that **increasing**	Bradford *et al.* (2012)	Belgium, Finland, Germany, Ireland, Italy, Scotland

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
				awareness on its own will not necessarily result in increased levels of preparedness. Found no correlation between worry and preparedness and suggest **communication strategies should not aim to evoke fear in vulnerable communities.**		
Preparation	**Economic**	Flood insurance	Telephone survey with householders (n=301)	No significant relationship was found between lack of flood insurance and risk perception or financial capacity to pay. However, perceived social response was related to insurance coverage. **Individuals are more likely to insure themselves against flooding if they expect the same action from other people similar to them or if they expect affirmation from members of their intimate social circles, i.e. family members or friends.** In contrast, apathetic or negative responses from other people may discourage voluntary adoption of insurance.	Lo (2013)	Brisbane, Australia
Preparation	**Institutional / infrastructure / community**	Environmental Competency Group	Six meetings at two-monthly intervals with local residents (n=8) and academic scientists (n=5). Further contact between meetings.	In this 'experiment', the position of scientists with respect to flood risk management was fundamentally changed and knowledge regarding flooding was co-produced between scientists and local residents. This led to the development of a flood mitigation model although the researchers' initial aim was not focused on finding solutions.	Lane *et al.* (2011)	Pickering, Yorkshire, UK
Preparation	**Community**	Resilience within rural communities	Structured interviews with farmers n=29 Structured interviews	Paper argues for an urgent need to strengthen local communities and to make them the primary bulwark against any future disaster and to support those agencies currently working towards this end. **It is the coherence and**	Smith *et al.* (2011)	Manawatu, New Zealand

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
			with key agencies n=17	**strength of communities that underpin the capacity of individual farm households to respond to adverse events.**		
Preparation / recovery	**Institutional**	Learning Alliances and active learning		A Learning Alliance (LA) is defined as a 'group of individuals or organisations with a shared interest in innovation and the scaling-up of innovation, in a topic of mutual interest'. Learning and Action Alliances (LAA) were set up in Yorkshire to help deliver an adaptive approach to FRM and to promote active and group learning. Early review of these has revealed a slow process of evolution in understanding that they differ from traditional partnerships and collectives set up to address particular problems or themes, and have at their heart, the wish to innovate beyond conventional norms. A tradition of top-down governance and incumbent regime application of regulations and funding in England and Wales for FRM and the need to comply with this, is so far acting as a barrier to many of the stakeholders in developing these effective and visionary LAAs.	Ashley *et al.* (2012)	Yorkshire, UK
Preparation / recovery	**Community/ economic / institutional**	Exploring 'resilience' in different communities before and after flood events	Three coastal towns Questionnaire n=343 Focus groups with n=24 Hull Semi-structured interviews and diaries n=42	Chapter draws on two pieces of research to argue that the recent shift towards the Flood Risk Management (FRM) approach, with its associated shift of responsibility towards the individual, is an example of the **risk society** at work. Decades of support for structural solutions, combined with the increasing challenges of climate change, have allowed the expansion of communities into flood-prone areas, thus increasing the risks to individuals when these defences fail. In acknowledging that floods are too indeterminate to 'know' or to entirely prevent, the FRM authorities have positioned	Deeming *et al.* (2011)	Cleveley, Mablethorpe and Morecambe Hull, UK

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
			Project steering group	themselves as simultaneously responsible and yet unaccountable. Researchers urge for more involvement of and engagement with the public at risk not only to raise awareness but also to challenge institutional understanding and behaviour. They also highlight the importance of paying more attention to how people can be better supported during the recovery process because of a 'recovery gap', which sees flooded residents trapped in the middle of a very individualising process having to negotiate themselves through the maze of agencies and companies involved in flood recovery.		
Post-flood/preparation	**Institutional**	How local flood knowledges are being captured, used and integrated into resilience planning	Interviews with officers, councillors, community members Use of web resources Action research as part of 3-year project	Discusses **how local knowledge can be captured and used**. Mentions how local knowledge can be fed into Community Risk registers and Community Flood Plans. Local flood knowledges have the potential to be better applied by communities and experts in different stages of the Disaster Response Spiral - in preparation, anticipation in warning stages, hut also in coping during an emergency, when official responses are challenged. In considering issues of scale in relation to types of knowledge, this **paper suggests that local knowledge can in fact be 'expert' in large scale mapping of flood processes**. There is evidence that there are **concerted attempts being made to take local knowledges seriously as 'authoritative knowledge'** vital to successful resilience planning/management alongside more traditionally recognised expert flood	McEwen and Jones (2012)	Gloucestershire UK

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
				science knowledge.		
Post flood / preparation - barriers	**Infrastructure**	Case study of cause, effect and non-structural mitigation following PLUVIAL flood event	Face-to-face questionnaire interviews with flooded householders (n=44) Attendance at meetings Interactive workshop Discussion with officers	Study has shown that the **plethora of agencies, combined with the fact that many public services are now in the private sector, creates a lack of cohesion** and invariably constrains effective responses to urban pluvial flood events. There is also a tendency for one agency to apportion the blame for flooding (or a lack of response to it) to another agency. The study has also highlighted that the **general public are confused about who does what and who is responsible for pluvial flood risk management, and are ill-informed about how best to protect their properties.**	Douglas *et al.* (2010)	Heywood, Manchester, UK
Preparation – barriers	**Infrastructure**	Understanding barriers and incentives	Interviews (n=23 with 27 respondents)	People with some experience of household flooding are more than six times as likely to take resilience or protection measures. **Protection must not only *be* effective but also needs to be supported by demonstrable evidence of effectiveness or by trustworthy advice on effectiveness.** Householders tend to hold the state responsible for maintaining that feeling of safety, especially where the state is seen as responsible for having compromised that feeling.	Harries for Defra (2010)	UK
Preparation – barriers	**Infrastructure**	Understanding attitudinal barriers related to taking protective measures	Semi-structured interviews (n=40)	People sometimes put their 'ontological security' above their physical security (According to Giddens, an ontologically secure person is someone who is free from existential doubts and who is able to believe that life will continue in much the same way as it always has, without threat to the familiar representations of time, space and identity). The mental suppression, by	Harries (2008)	UK

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
				householders, of awareness of risk can be seen as instrumentally rational, for it protects their ontological security and, hence, their mental health. **This article makes an argument for greater consideration of the role of emotions**. As emotions are primary to rational thought and do not necessarily enter consciousness, this implies the need for a methodological shift towards research methods that look beneath the superficial meanings of what people say and explore the representations and discourses that shape their speech and actions.		
Preparation / barriers	**Infrastructure / economic**	Emotional consequences of adaptive behaviour	Secondary analysis of previously conducted survey n=555	Concluded that **beliefs about the impact of protection measures on anxiety and feelings** deserve more attention than they have previously received. People who said they expected to be flooded in the next ten years were almost twice as likely as others to have taken protective measures and those that said they expected to move away from at-risk areas were less than half as likely to have done so. Also found **no correlation between protective behaviour and expressed beliefs about its financial implications** (the cost of the measures, the promise of long-term savings, and the impact on insurance terms). The revealed importance of anticipated emotions for decisions about flood protection indicates that policy makers ought to be concentrating more on promoting the emotional benefits of adaptation.	Harries (2012a)	UK
Preparation – barriers	**Infrastructure**	Understanding household	focus groups (n=21)	Chapter suggests that before they will act to protect themselves, their families and	Harries (2013)	UK

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
		ers' response to flood risk	interviews (n=21) paired-interviews (n=8) (re-analysis of Quantitative research – telephone survey n=555)	their property, people not only need information and the necessary financial resources, but also reassurance about the implications of protective action for their emotional security		
Preparation – barriers	**Community/ infrastructure**	Identifying obstacles and incentives for adaptation – coastal flooding in two urban environmental justice communities	Three community workshops 1- n=56 2- n=50 3- n=70 (some repeat participants)	Four key lessons were learned from this work: 1) **Images are very powerful communicators** - flood maps are a very good tool for engaging audiences, but even more, the conceptual design images of adaptation strategies (such as the modular sea wall) were found to be essential in turning what could have been an attitude of complete dismissal into one of potential acceptance of such options; 2) **understanding existing cultural knowledge and values about adaptation to climate change must be part of the framework adaptation planning**, if progress is to be made at the local level; 3) **one must be prepared to present funding resources along with the adaptation strategies** as we found this to be the biggest concern in each community; the willingness to be involved in adaptation planning was there, but the financial resources for implementing them were not; 4) despite the dire predictions and possibly devastating consequences of climate change, **engaging local residents at the beginning of the planning process can create important educational opportunities and develop the rapport, trust and**	Douglas *et al.* (2012)	Boston, USA

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
				consensus that is essential for moving from concept through implementation.		
Preparation	**Institutional**	Collaborative Modelling	Multidisciplinary methodology was developed with three interlinked types of methods and tools: the social science methods, the modelling methods, and the web-based supporting methods and tools	The main objective of the project was to develop and test an advanced methodology for enhancing the resilience of local communities to flooding. Through **collaborative modelling, a social learning process was initiated that enhances the social capacity of the stakeholders due to the interaction process.** The other aim of the project was to better understand how data from hazard and vulnerability analyses and improved maps, as well as from the near real-time flood prediction, can be used to initiate a public dialogue (i.e. collaborative mapping and planning activities) in order to carry out more informed and shared decision-making processes and to enhance flood risk awareness. Conclude that gathering and inclusion of "local" knowledge is essential for participatory governance in FRM. This is particularly true for the successful development and implementation of collaborative modelling methods and tools.	Evers *et al.* (2012)	UK and Germany
Post-flood/ recovery	**Institutional**	Bradford - Flood Local Action Plans, Water Management Inquiry Glasgow - Strategic Drainage Plan	Bradford-interviews (n=10) Glasgow-interviews (n=16) Review of documentation Attendance at meetings	In Bradford, and more so in Glasgow, **flooding is being represented as a community and economic issue** - this creates space for other actors to be brought into flood risk management and allows the role of flood engineering to be reconfigured. **Key factor for success - 'policy entrepreneurs'**. Without their presence within the advocacy coalition actor networks and their positioning in the institutional spaces, acting as promoters and working to ensure the	Cashman (2009)	Bradford and Glasgow, UK

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
				acceptance of the shared vision then the outcomes would have been different. Indeed there may not have been any significant institutional or policy developments at all. The key role of policy entrepreneurs is evidenced by the reported weakening of the institutional structures that emerged in the wake of the flooding incidents following the withdrawal of certain individuals.		
Post-flood/ recovery	**Institutional**	Water management advisory group (which conducted the inquiry reference above) Flood Action Plans (FLAPS)	Interviews with stakeholders, local councillors, senior policy advisors, government officers and members of local NGOs (n=10)	The **dispersal of responsibility for the management of different stages in the flood management cycle across a multiplicity of agencies has served to isolate actors and create institutional barriers to cooperation** at both the individual and the collective level. Bridging this divide both within and across organisations was seen as an effective coping mechanism that at least allows for a better understanding of what can and cannot be achieved. It also encouraged individuals within organisations to go beyond the strict limits of their responsibilities and create new pathways for cooperation. The inquiry allowed a high degree of reflection and shared learning. Importantly, it brought about a greater realisation of the constraints, opportunities and institutional norms within which the various actors were situated as well as a sense that things had to change. **The FLAPS process, by allowing people in the community to vent their anger and seek answers, led to a greater understanding and appreciation of the complexities of flooding.** The coming together as a group of individuals also enhanced the bonding and	Cashman (2011)	Bradford, UK

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
				sense of community. The evidence that some community groups formalised their relationship and took on their own forms of community action would seem to support this. In other words, **there does seem to be evidence that suggests engagement and understanding can be transformative within a community. In terms of building and strengthening social networks and cohesion, increasing awareness, information and preparedness, they led to greater individual as well as community resilience.**		
Preparation /during flood/ recovery	**Institutional /community**	Case-studies in 3 European countries as part of Floodsite project	Questionnaire survey Germany n = 404 Italy n= 686 UK n = 2,124 (re-analysis of earlier surveys) Interviews Germany n=22 Italy n=18 Focus groups Italy n=6	In all three countries, researchers **found the context to be essential when analysing flood events and their impacts** on social groups and local communities. Moreover, **each event may have different impacts on the households and communities affected**, de-pending upon levels of preparedness and other factors. A similar flood event in terms of depth, duration, etc. can have very different effects on different people. Research findings also indicate that some social groups within communities are more likely to need specific targeting and support (though not necessarily do under all conditions): • those with no previous flood experience, • those who have recently moved to an area, • those with lower social status, • those living alone without disposing of a social network outside their home, • households with long term ill or disabled members, • those living in vulnerable	Steinfuhrer (2009)	Germany, Italy and UK

Stage in process	Resilience category	Intervent-ion	Methodol-ogy	Key points	Authors	Location
				housing (like mobile homes or bungalows), and • older people (in particular the oldest-old not living in homes for the aged). In the case studies, **most help during and after a major flood event was provided by informal networks (family and relatives), but also by voluntary organisations, hence by both informal and formal networks**. The research provided evidence that adopting personal preparatory measures, being informed about public flood protection, feeling prepared and, finally, being prepared are four distinct issues each of which re-quires different approaches in the course of flood risk management. **There is no direct, immediate, and uni-vocal link between perceptions, opinions, and attitudes on the one hand and actual actions and behaviours on the other**.		

Appendix 4: Summary Table – Section 7

Author/Date	Type of paper	What is being measured?	What is being reported?	Database (D) or expert (E)
Balica *et al.* (2012)	Journal	Coastal flood vulnerability	Development of a Coastal City Flood Vulnerability Index (CCFVI) based on exposure, susceptibility and resilience to coastal flooding.	D
Cutter, S *et al.* (2010)	Journal	Resilience	Development a methodology and a set of indicators for measuring baseline characteristics of communities that foster disaster resilience.	D
Cutter, S. *et al.* (2010)	Journal	A social vulnerability algorithm (SOVI)	An assessment of quantitative procedures for evaluating social vulnerability as it relates to flood hazards.	D/E
Djordjevic, S. *et al.* (2011)	Journal	The cost-effectiveness of flood resilience measures.	This project being reported aimed to quantify the cost-effectiveness of resilience measures and integrative and adaptable flood management plans.	D
emBRACE WP 1 (2012)	Project report	Disaster resilience	The report reviews how resilience is assessed and operationalized in existing studies of resilience.	E
ENSURE (2009)	Project report	Vulnerability of structural, territorial and economic systems.	The report reviews methodologies to assess vulnerability of structural, territorial and economic systems.	E
ENSURE (2011)	Project report	Vulnerability and resilience of communities facing natural and na-tech hazards.	A methodological framework to assess vulnerability and resilience across different temporal and spatial scales.	E
Ewing, L and Synolakis, C. (2011)	Conference proceedings	Community Resilience Index (CRI)	A report of a bare-bones Community Resilience Index (CRI) that has been developed, based	D

Author/Date	Type of paper	What is being measured?	What is being reported?	Database (D) or expert (E)
			upon lessons learned from recent coastal disasters.	
Godschalk, D. *et al.* (2009)	Journal article	Benefit-cost analysis combined with case study analysis.	A report of a study to pair aggregate benefit-cost analysis (BCA) with in-depth community case studies to provide a more complete picture of the benefits and costs of natural hazard mitigation projects in order to supplement quantitative findings.	D
Kuhlicke, C., Scolobig, A., Tapsell, S. Steinfuhrer, A.and De Marchi, B. (2011)	Journal article	Social vulnerability assessment – case studies	The paper assesses social vulnerability to flooding in Italy ,Germany and UK case studies – difficulty of developing cross-country measures	D
Lumbroso, D., Stone, K. And Vinet, F. (2011)	Journal article	Assessment of emergency plans	The paper developed an 22 metrics to measure emergency flood plans in UK, France, Wales and Netherlands	D
Menoni, S., Molinari, D. Ballio, F., and Tapsell, S. (2012)	Journal article	Vulnerability assessment	The application of a vulnerability assessment tool to a case in Italy of flash flooding.	D
Steiner, A. and Marianna Markantoni, M. (2013)	Journal article	Community resilience assessment	Development of quantitative and qualitative measure of community resilience with case study in Scotland in general – not related to flooding	D
Twigg, J. (2009)	Guidance Document	Disaster resilience	Characteristics of a disaster resilient community and progress towards it	D/E
Yoon, D. (2012)	Journal article	Assessing social vulnerability	This study empirically compares deductive and inductive index development and indicator aggregation methods in assessing social vulnerability to	D

Author/Date	Type of paper	What is being measured?	What is being reported?	Database (D) or expert (E)
			natural disasters in the Gulf of Mexico and Atlantic coastal areas	
Zahran, S. Brody, S. Peacock, W., Vedlitz, A. and Grover, H. (2008)	Journal article	Measuring social vulnerability in different locations	The paper examines whether geographic localities characterised by high percentages of socially vulnerable populations experience significantly more casualties due to flood events, adjusting for characteristics of the natural and built environment. US	D

Appendix 5: Example of Completed Data Extraction Form and Quality Assessment

Citation Details	
Author(s)	S N Lane, N Odoni, C Landstrom, S J Whatmore, N Ward and S Bradley
Year of publication	2011
Title of paper	Doing flood risk science differently: an experiment in radical scientific method
Title of publication **(e.g. book, journal, report)**	Transactions of the Institute of British Geographers
Vol., Issue, Pages	Vol 36 pp15–36
Reference number	
Nature of Study	
Resilience category	Institutional
Funding stream / project context	funded by grant RES-227-250-018 from the Rural Economy and Land Use programme of three UK research councils (BBSRC, ESRC and NERC) and Defra,
Location	Pickering, Yorkshire
Date of study	2007-2008
Purpose of study / aims	The paper describes an experiment in which the position of scientists with respect to flood risk management is fundamentally changed and in which knowledge regarding flooding was co-produced between scientists and local residents.
Methodology (quant, qual, mixed)	Qualitative
Research design (what they did)	They recruited eight local residents to sit on a Flood Research group through advertisements placed in shop windows, community notice boards, including in a supermarket and a doctors' surgery, the local library, and museum networks as well as the local press. Five academics, a facilitator and a meeting manager and recorder completed the group. All local members were offered four things, but were not promised that the RFRG would actually make progress with reducing Ryedale's flood risk: 1. an opportunity to 'make something together' – though it wasn't clear what 2. an opportunity to be part of, and help shape, a national project about how scientists and local residents can work together more effectively 3. intellectual engagement in a collective endeavour, learning about different experiences and understandings of the local water environment and 4. an opportunity to produce some oral testimony (through life history recordings) of people living in Ryedale at the time of the 2007 floods. Six meetings of the Group took place at two-monthly intervals between September 2007 and July 2008 with constant contact in between via emails, one to one meetings with each member in between every meeting, telephone conversations, website co-production and co-production of written material. Also set up a reading group on consultants' reports. All meetings were video recorded and transcribed.
Intervention tested,	Environmental Competency Group (which residents called the Ryedale Flood

if any	Research Group)
No. of participants	8 local residents, 5 scientists
Target population (eg vulnerable groups, ethnic minority)	
Main findings	The supposed tension between the universal knowledge of Science and the local understandings generated through everyday life (Irwin 1995; Callon 1999) may be more a consequence of how we, as experts, classify expert and vernacular knowledge than the nature of that knowledge itself. Not only are there similarities in the processes by which knowledge is acquired, but also in the content itself. Local members had a rich understanding of the fundamentals of hydrology and hydraulics, of Newtonian physics. This knowledge was not simply local, as is often portrayed (e.g. Callon 1999), but universal. Local members possessed the expertise necessary not only to guide what the model should do but to contribute to the conceptual development of the model itself. Moved the idea that a model should travel to one where the process of model building should travel. In the RFRG, the burden of effort shifts from making an off-the-shelf model work in a particular place to developing a model directly suited to that place. The latter process may be much more cost effective than the former and we have estimated that the cost of doing the modelling using our approach may actually be substantially less than the way in which a consultant might conventionally pursue the task (see Ryedale Flood Research Group 2008).
Summary of conclusions	
Main recommendations	

Quality Assessment			
	Yes	**No**	**Not applicable/sure**
1. Was there a clear statement of the aims of the research? Was it related to the REA questions?	yes		
Methodology			
2. Was the methodology chosen appropriate?	yes		
Research design			
3. Was the research design appropriate to address the aims of the research? Is there a discussion of the choice of research design?	yes		
Sampling			
4. Was the recruitment strategy appropriate to the aims of the research? If representative sampling was used, was the sampling frame (selection of participants) representative of the population being studied?	yes		
Data collection			
5. Were the data collected in a way that addressed the research issue? Were the methods chosen clear and were they justified?	yes		
6. If there was a comparison or control group, were they similar enough to the intervention group to be comparable?			Not applicable
7. If qualitative research design, has the relationship between	yes		

researcher and participants been adequately considered?			
Ethics			
8. Have ethical issues been taken into consideration? Whether consent was obtained from participants and information sheets provided.			Not sure
Data analysis			
9. Was the data analysis sufficiently rigorous? Was it sufficiently described and an appropriate sample analysed? For a quantitative analysis, are enough data presented for results to be valid and useful (i.e. on both the dependent and independent variables).	yes		
10. Is there a clear statement of findings? Whether the studies gave enough depth and detail to give confidence in their findings. Whether the studies assessed the relevance of their findings to the wider population and/or context.	yes		