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Executive Summary

As set out in the 25 Year Environment Plan, the government intends to boost the long-term resilience of our homes, businesses, infrastructure and the environment and reduce harm from natural hazards including flooding and coastal erosion. The Draft National Flood and Coastal Erosion Risk Management (FCERM) Strategy for England calls for transformational action on resilience and adaptation. The move towards "flood resilience" from "flood risk management" reflects the need to diversify strategies to enable people to live well in the context of floods. However, there is no one agreed definition of resilience and its conceptualisation and its application varies.

Defra commissioned this project to review the concept of flood and coastal erosion resilience and how it can be used in a resilience approach for FCERM in England and Wales. The report describes the main frameworks for defining and conceptualising flood resilience, drawing on a growing body of academic and 'grey' (not peer-reviewed) literature as well as examples from practice in the UK and internationally.

The first section describes the elements of the project:

- A Quick Scoping Review covering the main approaches to flood resilience currently in existence and the use of metrics to implement resilience approaches.
- A summary of all the responses to Defra's 'Call for Evidence on Flooding and Coastal Erosion'
- Two evidence review and policy implementation workshops involving FCERM policymakers and cross-government practitioners.

The main findings from the Quick Scoping Review are summarised in the second section. The review found that the resilience literature lacks sufficient theorising and empirical testing to enable predictions about the combination of factors that could increase or decrease aspects of resilience. However, we identified a number of frameworks that provide a systematic approach to assessing and supporting the development of resilience in the context of natural disasters and flooding in particular. The report provides a detailed assessment of five of these: Baseline Resilience Indicators for Communities (BRIC) (Cutter et al., 2014) and applied in the Community resilience index for Norway (Shertzer et al., 2019); Flood Resilience Measurement Tool (FRMT) (Keating et al., 2017, Campbell et al., 2019); emBRACE community resilience framework (Kruse et. al., 2017); City Resilience Index (Rockefeller Foundation / Arup, 2015); Australian Natural Disaster Resilience Index (ANDRI) (Parsons et al., 2016).

We examined the metrics and indicators used in each of these approaches, as well as a set of flood hazard metrics developed for the UK: Neighbourhood Flood Vulnerability Index (NFVI), Social Flood Risk Index (SFRI) and Relative Economic Pain (REP) as introduced by Sayers et al. (2016). All the reviewed assessment frameworks/metrics are indicator

based, but some apply a top down assessment and mostly use secondary data while others apply bottom up evaluation approaches using a mix of primary and secondary data sources. Other differences are the geographical scale at which resilience is measured and whether or not the indicators are combined to provide a numerical score for overall resilience.

In the discussion and recommendations section, the report describes the components that could be included in a resilience framework for FCERM in England and Wales:

- A clear definition
- Objectives and goals
- Identification of the capacities or capitals which support resilience of places / communities, to provide a holistic and systematic understanding of resilience
- Recognition of the qualities required by a resilient system, such as resourcefulness, robustness, rapidity and redundancy.

This section also discusses the need for the resilience approach to fit with the work of other government departments, RMAs and public and private bodies involved in FCERM. A clear approach to flood and coastal erosion resilience from Defra and the Environment Agency, which recognises work already being done by others, would help actors in different sectors take appropriate decisions and actions to embed resilience.

Finally, the section on actions and challenges explores the changes that will be required to implement a resilience approach in FCERM in England and Wales. The report sets out some actions to start this process and identifies likely challenges. It identifies gaps in knowledge which could be addressed by future research.

Introduction

The concept of resilience is one that has become increasingly familiar across the flood and coastal risk management cycle in particular, and the emergency planning literature in general: from "community resilience" (Cabinet Office, 2011), to "Property flood resilience" (Bonfield, 2016), "Infrastructure resilience" (National Infrastructure Commission - NIC, 2018) and "resilient places" (Environment Agency - EA, 2019).

As set out in the 25 Year Environment Plan, the government intends to boost the long-term resilience of our homes, businesses, infrastructure and the environment and reduce harm from natural hazards including flooding and coastal erosion. In addition, the Draft National Flood and Coastal Erosion Risk Management Strategy for England sets out how flood and coastal erosion risk management (FCERM) can be best delivered over the coming years using an approach based on the concept of resilience[1].

As Samuels (2019) notes in relation to the Draft National FCERM strategy "*it is clear that the concept of resilience is set to become a policy action*" (editorial p.1). It has been widely accepted for a number of years (see e.g. Defra, 2004) that strategies built solely on resisting flooding and reducing flood risk are unlikely to be successful. "*Reliance only on flood defense (sic) and, seemingly associated, increasing capacity to resist is undesirable when taking into account current and potential future flood risks in times of urbanization and climate change (Holling and Meffe 1996, Kundzewicz and Takeuchi 1999, Liao 2012).*" (Hegger et al., 2016, p.52).

The Draft National FCERM Strategy calls for transformational action on resilience and adaptation. The move towards "flood resilience" from "flood risk management" is in part a reflection of the need to diversify strategies to continue the direction of travel towards living well in the context of floods". This project is part of the process of considering what moving from the rhetoric to the practice of resilience might look like in the context of FCERM in England.

As an area of academic study, resilience in the context of FCERM is relatively young and draws upon a range of disciplines from engineering to sociology. There is a plethora of definitions and frameworks with some consensus on core aspects but "*there is no agreed definition of resilience*" (Ruszczyk, 2019), it is used in different ways for different contexts. No "off the shelf" tried and tested approaches exist that could be easily transferred to FCERM in England and Wales. Given this, it is timely to consider the similarities and differences between those frameworks, to ensure that "*practitioners, policy-makers, and*

[1] Under the Flood and Water Management Act (2010) it is the EA's role to produce a statutory national flood and coastal erosion risk management strategy for England, setting out the roles and responsibilities of all risk management authorities. In Wales the responsibility lies with the Welsh Ministers.

researchers have a shared vocabulary for and understanding of resilience and how it is assessed" (Samuels, 2019, editorial, p.1).

The primary objective of this project was to review the concept of flood and coastal erosion resilience and how it can be used in a resilience framework for managing FCERM in England and Wales.

The specific objectives were to:

- Provide evidence from peer-reviewed and grey literature and unpublished reports on the main approaches to flood resilience that are currently in use and also look at the use of metrics in implementing resilience approaches.
- Provide a summary for publication of all the responses to Defra's 'Call for Evidence on Flooding and Coastal Erosion' to inform the development of the Government's policy on flood resilience.
- Support the consideration by FCERM policymakers and practitioners of resilience concepts, frameworks and metrics, how these could best be implemented in policy and how to address any barriers to implementation.
- Facilitate cross-Government consideration of how to align concepts of resilience, including the identification of the most suitable concepts and metrics and how they could be put into operation.
- Provide an assessment of the advantages and disadvantages of each resilience approach identified.

This report describes the methodology used, the steps in the review, the main findings from the evidence about existing approaches to flood resilience and the conclusions from these. It also provides some high-level recommendations to Defra on the development of a flood resilience approach in England.

Approach

The approach to the review of evidence on the concept of flood resilience included:

- An expert driven Quick Scoping Review of literature supported by expert interviews
- Call for Evidence Analysis
- Collation of information from two policy implementation workshops

Quick Scoping Review

In order to review the literature, we carried out a Quick Scoping Review using an expert-driven approach to gather relevant documents from three types of sources:

1. Expertise within the project team (Prof. Dennis Parker, Jaap Flikweert, Dr. Clare Twigger-Ross and Paula Orr)

2. Papers provided by members of the Steering Group
3. Papers provided by the Call for Evidence
4. Expert interviews

The review focused on three research questions agreed with the project Steering Group (see Box 1 on page.10). The initial number of papers provided by Sources 1 and 2 totalled 80. An initial assessment and further prioritisation of relevance to the research questions gave a starting group of 28 papers for the scoping review.

The papers from Source 3, the Call for Evidence, totalled 33, with eight duplicated documents from Sources 1 and 2. The remaining 25 documents were reviewed for relevance. 20 were considered not to present significantly different evidence from the papers already reviewed (over half were written by the same authors). The remaining five documents were included in this review.

Expert interviews (Source 4) were also conducted in order to reflect on or complement the literature being reviewed. Five experts were interviewed suggesting seven new sources, which have been considered in this scoping review.

All the documents from all sources (1, 2, 3 and 4) were logged and clustered in an Excel spreadsheet. The synthesis of the evidence is structured around the research questions and priority areas identified in the specification and referred to in the Main findings from the Quick Scoping Review of this report. Any additional key themes emerging from the evidence were drawn out and brought into the analysis.

A more detailed approach to the review is presented in the Quick Scoping Review (Appendix 1).

Call for Evidence

To inform the development of future Government policy on flooding and coastal erosion, Defra issued a Call for Evidence on 8 July 2019. The call for evidence was open for six weeks and responses were invited from anyone with an interest in the topic. The Call For Evidence asked questions in relation to a selection of the flood and coast policy issues that the government is currently considering. A total of 72 responses were received. The analysis of the responses involved creating a set of codes linked to the main aspects identified in the Call for Evidence document.

The analysis of the results of the Call for Evidence has been published by Defra.

Collation of information in two Defra and EA resilience evidence review and policy implementation workshops

Two policy implementation workshops were organised with stakeholders from government departments and other organisations, to provide a further opportunity to discuss the topic and the practical implications of the implementation of a resilience approach. The second workshop also provided an understanding of how other government departments conceptualise and apply resilience in their work and looked at how infrastructure providers make their assets and operations resilient to a range of risks. The workshops took place in London on 14th October (13 participants) and 5th November 2019 (21 participants). Workshop records were produced after each workshop and have been drawn on for this evidence review.

Main findings from the Quick Scoping Review

This section provides the main findings from the Quick Scoping Review together with key findings from relevant parts of the Call for Evidence.

Existing approaches to flood resilience

The Quick Scoping Review examined a number of approaches to flood resilience from both academic and grey literature (produced by individuals or organizations outside of commercial and/or academic publishers). The grey literature was primarily from UK government sources. Specifically, it examined the research questions shown in **Error! Reference source not found.**.

Box 1: Research questions

1. How has resilience been defined and conceptualised in regard to natural hazards generally and flooding in particular?
   - To what extent have different aspects (e.g. social, technical, etc.) of resilience to natural hazards generally, and flooding in particular, been conceptualised or operationalised as one "overall resilience" concept? What challenges, advantages and disadvantages of bringing these aspects together, conceptually, methodologically and practically, are considered in the literature?
   - How have definitions and conceptualisations of resilience generally and flooding/natural hazards in particular been expressed or reflected across government in England and Wales and specifically with respect to FCERM policy?
2. What different metrics, indicators or standards have been used to describe, measure, assess or set targets for resilience to natural hazards, generally and flooding in particular?
   - What are the challenges in developing metrics for different aspects of resilience to natural hazards generally and flooding in particular?
   - What evidence is there around the implementability of these metrics as tools for driving actions to support government policy?
3. How do the identified resilience frameworks (both concepts and metrics) perform against the following criteria: addressing a range of risks and impacts; capable of being tailored to geographical area and local variation; level of ambition to drive action; appropriate distribution of costs and benefits; meaningful to a range of audiences; enabling identification of timescales for implementation of measures: short- to long-term; appropriate and feasible allocation of roles and responsibilities; and feasibility and affordability of data collection and verification?

Full discussion of each research question and its sub-questions can be found in the Quick Scoping Review (Appendix 1). In the following sections the key findings related to each question are discussed.

How has resilience been defined and conceptualised in regard to natural hazards generally and flooding in particular?

Academic definitions of resilience

Overall, the evidence review found that resilience within the academic literature is described as covering a number of key characteristics:

- the ability or capacity to **prepare for, respond to, and recover** from damaging hazard events
- capacities to withstand or absorb the impact of a hazard and to **maintain functionality** or more positively to **enhance wellbeing** or **survive and thrive**
- being **reactive/stationary or proactive/dynamic**, with the former emphasising a "bounce back" to an original state, and the latter emphasising a "bounce forward"
- capacities to **adapt or transform** to a new normal that enables a better recovery when next faced with a shock or stress and does not **reproduce existing vulnerabilities**
- capacities to manage change **by learning and reorganising**
- a distinction between inherent and adaptive resilience. **Inherent resilience** is the pre-existing or pre-event resilience within a community, whereas **adaptive resilience** is the ability of individuals, stakeholders, or communities **to learn** from and respond to changes precipitated by some hazard event
- **resilience to what** (e.g. to natural hazards, flooding) and **of whom/what** (e.g. physical and social structures at different spatial scales: household, neighbourhood, city, region, country).

The concept of capacities was a key one that emerged from the literature. Sometimes termed "capitals" or "resources", this refers to the skills, knowledge or structures that communities or individuals may or may not have to support resilience. For example, having a flood defence is likely to increase resilience to flooding. Other capacities might be more general such as having a job which in turn should mean a household will have more money to be able to recover after a flood. Those skills, knowledge, or structures may exist before an event or they may emerge during or after an event. Capacities cover a number of different areas e.g. social, environmental, infrastructure, community, institutional and economic (Cutter et al, 2014) because it is recognised that resilience is a multidimensional concept. The resilience of a community or system can be assessed by reviewing the different capacities and profiling where greater input maybe required. The frameworks summarised in Table 2 all include capacities and show how they could be used to assess the resilience of places and communities.

A number of frameworks describe qualities or properties of resilient systems. These are sometimes summarised as "the 4 'Rs'"[2]. However, this is potentially misleading because some frameworks refer to more than four qualities and even when there are four, they are not always the same qualities.

Examples of the different qualities of resilient systems include:

- Cabinet Office (CO, 2011a) Infrastructure resilience: ***resistance, reliability, redundancy, response and recovery***
- Zurich Flood Resilience Alliance Flood Resilience Measurement framework (Keating et al., 2017): ***robustness, redundancy, resourcefulness and rapidity***
- Rockefeller Foundation / Arup (2015) City Resilience Index: ***reflective, robust, resourceful, inclusive, redundant, flexible, integrated***

Interestingly, there is limited use of the term protection across the definitions. This may be because protection might be seen to emphasise, in the case of flooding, building higher flood defences invoking the idea that flooding can always be prevented through engineering. Further, protect suggests that the system does not change with exposure to the hazard, in this case flood and coastal erosion, which negates the need to adapt. Given the uncertainties of climate change there is a consensus that a wider range of measures is going to be required. Keeping out flood waters and preventing coastal erosion is not always going to be possible, and a shift away from a prime focus on reducing probability is emphasised. Instead, the terms resistance, absorption and robustness are highlighted as qualities of resilient systems (discussed in more detail in this section), focussed on reducing the impacts of the event, but sitting alongside qualities of redundancy and resourcefulness which are adaptive approaches to flood and coastal erosion consequence management. The terms resistance, absorption, and robustness capture the aspects of protection and prevention from a systems perspective. Cutter (2016) does include "absorb" in her broad definition:

"This paper takes a broad definition of disaster resilience to infer the ability to prepare and plan for, ***absorb****, recover from or more successfully adapt to actual or potential adverse events (NRC 2012)."* (p.742, our emphasis).

A further point in relation to the shift towards a wider framing of Flood and Coastal Erosion Risk Management (FCERM) relates to the consideration of resilience of flood assets. There is a move to ensure that assets in themselves are resilient; this goes beyond the traditional 'single design point' approach, by also considering aspects such as performance under extreme loading, residual performance after failure (including repairability) and the asset's adaptive capacity. As part of this project a short piece of

[2] Referring to the Cabinet Office's components of Robustness, Resourcefulness, Rapidity and Redundancy (see Quick Scoping Review, Appendix 1, p.40).

work was commissioned to investigate how far it might be possible to measure asset resilience with an ultimate goal of understanding how much asset resilience contributes to the overall resilience of a place and its communities (see Appendix 2). This work shows how the concept of resilience can be used and understood in relation to one aspect of the FCERM system.

Whilst as a scientific area of enquiry resilience is still in its infancy, in part because of its multidisciplinary roots, we suggest that there is general agreement around these characteristics.

It should be noted that the definitions we examined focussed natural disasters or flooding, rather than coastal erosion, and that this is a potential gap that needs examining further.

Call for evidence: What we understand by the term "resilience"

The analysis of responses to the Call for Evidence question on 'What we understand by the term "resilience"', explored the understanding and application of this term. In summary, almost two-fifths of respondents said they used the concept of resilience in their own work. These included national and local public bodies, water and wastewater utilities, insurance companies and non-governmental organisations, as well as academics. This shows the current reach of the concept, clearly embedded within practice of those involved in FCERM.

Many respondents associated the concept of resilience with having a range of measures for dealing with flooding. They felt that the table in the Call for Evidence (see Table 1), which shows four concepts of resilience, was a good illustration of the range of approaches.

Table 1: Four concepts of resilience, from Defra's Call for Evidence

Overall approach	Concept of resilience	What it means	Relevant flood and coastal erosion approaches
Maintain the current situation	Resilience as **resistance**	Protecting ourselves against threats and hazards	Building and maintaining flood and erosion defences.
	Resilience as **bounce-back**	Getting back to normal, recovery	Clearing up after a flood, repairing properties, rebuilding damaged infrastructure back to its previous state.
	Resilience as **adaptation**	Adjusting to a new normal	Adapting properties and infrastructure so that less damage

Change to do things differently			will be caused when they flood, accepting that some fields will be flooded when there is heavy rain.
	Resilience as **transformation**	Owning the need to make significant change	People living in a village on a rapidly eroding coastline deciding to move to a less risky area.

This links to our earlier point about the concept of resilience increasingly concerning the diversity of strategies used to address flooding.

However, other respondents felt that some of the types should not be included in a concept of resilience, with many respondents saying that it was misleading to include resistance as a type of resilience. Typically, resistance might be thought of as more reactive resilience which conceptually can be seen as being at odds with a more proactive, adaptive and transformative resilience. However, at the level of practical measures, resistance measures are always likely to be part of the portfolio within FCERM. As discussed later in this document, a key change in moving towards flood resilience may well be to enable a portfolio of measures to be evaluated alongside each other rather than having resistance as the primary response.

The responses to the consultation from the professional coastal management community were cautious, highlighting the fundamental differences between flooding and coastal erosion. The concept of resilience can work for coastal erosion too, but this has to reflect those differences. The key difference is that coastal erosion, by its nature, causes loss / damage that is unavoidable (it is only a matter of time when the loss or damage happens) and permanent.

Historically, resilience has been seen in the professional FCERM community as interventions to reduce consequences and impacts if the hazard occurs. Understood in this way, the idea of resilience interventions in the case of coastal erosion may not be meaningful. However, the broader definition of resilience encompasses all possible interventions to address coastal erosion. This includes protection measures to delay the loss of features (which are captured in Outcome Measures 1 and 3 of the Government's current FCERM policy (Environment Agency, 2014)), but can also include the 'coastal change adaptation' measures that have been explored in recent years through Defra's Coastal Pathfinder (Fenn et al., 2015). Some authorities are further along the journey to enable roll-back of communities including planning, finance and extensive community engagement around long-term transformation (e.g. Bennett-Lloyd et al., 2019).

The responses in the consultation may also stem from a concern that a move toward a resilience-based framework for flood and coastal management may not apply well to coastal erosion and therefore shift emphasis away from the coast. There is a need for

clear communication to the professional coastal management community to clarify how coastal erosion will be encompassed in a resilience framework[3].

For the coastal management community, this could have the additional benefit of drawing together and integrating the two dimensions of their work: protection and coastal change adaptation. How the resilience framework could work for coastal erosion will need to be explored further in close collaboration with the professional coastal management community.

A conceptualisation of resilience as the capacity to deal with **change** and continue to develop (Davoudi et al., 2012) was seen as something that would need to be included in the approach adopted; with consideration given explicitly to how the concept could be applied in the context of coastal erosion. Without this, it was suggested that there is a risk that avoidable maladaptation could occur in coastal communities (Payo Garcia, 2018).

Call for evidence respondents also stated that stakeholders need to make efforts to communicate effectively about flood resilience. Some said that it was important to avoid misunderstandings about the relationship between resilience and resistance, as these could lull at risk communities into a false sense of security.

Resilience frameworks

What is missing from the resilience literature is sufficient theorising and empirical testing to enable predictions as to what combination of factors clearly increase or decrease aspects of resilience. However, there are a number of frameworks that provide detail on concepts and measurement that have been developed and provide a systematic approach to assessing and supporting the development of resilience in the context of natural disasters and flooding in particular. It should be said that from our research, only one framework was found that focuses directly on resilience to flooding, the others are focussed on natural disasters in general.

The evidence review examined six frameworks in detail. Some significant examples of approaches to assessing flood resilience were not included in the review because they address specific and more limited objectives. For example, the US Federal Emergency Management Agency (FEMA) National Flood Insurance Program Community Rating System is a voluntary incentive program that recognises and encourages community floodplain management activities. The programme recognises nineteen eligible community flood resilience activities, under four overarching categories (public information; mapping and regulations; flood damage reduction; and warning and response). Participating communities are rated according to their participation in these activities and receive increasingly higher discounts on their insurance depending on this rating (FEMA,

[3] It was not possible to include specific coastal representatives in the project's workshops. However, there have been informal conversations between project team members and coastal stakeholders which have informed this report.

2017). This system focuses exclusively on community measures and does not consider the range of capacities for addressing risks (i.e. human, social, natural, physical and infrastructure) or the roles and responsibilities of other actors.

The six frameworks selected are summarised in Table 2.

Table 2: Summary of the six resilience frameworks reviewed

Title of framework	Key components	Indicators/metrics (primary/secondary[4] data collection)	Resilience to what of whom/what?	Key papers	Use
Disaster Resilience of Place Model Baseline Resilience Indicators for Communities (BRIC)	Inherent and adaptive resilience 6 types of resilience: social, economic, housing/infrastructure, institutional, community, environmental	Indicators associated with each of the types of resilience. Uses secondary data	Disasters – natural hazards Communities	Cutter et al (2008) Cutter et al. (2010) Cutter et al. (2014)	Burton (2015) used post-Katrina Scherzer et al. (2019) used the BRIC in Norway Twigger-Ross et al. (2015) used in the FRCP
Flood Resilience Measurement Tool (FRMT)	5 capitals: human, social, physical, natural, financial 4 properties of resilience: robustness, resourcefulness, rapidity and redundancy 88 sources of resilience across the disaster risk management cycle and 7 themes 29 ex-post outcome indicators	Uses both primary and secondary data	Flooding Communities	Keating et al. (2017) Campbell et al. (2019) From the Zurich Flood Resilience Alliance	The tool has been tested in 118 communities across 9 countries described in Campbell et al.

[4] Primary data is data collected from first-hand sources through field work on site or with people/communities; secondary data is existing data from other sources.

Title of framework	Key components	Indicators/metrics (primary/secondary[4] data collection)	Resilience to what of whom/what?	Key papers	Use
DFID Disaster Resilience Framework	Four aspects: Context: resilience of what? Disturbance: resilience to shocks and stresses Capacity; exposure, sensitivity and adaptive capacities – key determinant of these are the resources that can be used. DFID use the 5 capitals from sustainable livelihoods framework (SLF): social/human, physical, political, financial, environmental/natural. Reaction: bounce back, bounce back better, recover but worse than before, collapse	Not clear if it has metrics associated with it	Disasters – shocks and stresses of System or process	DFID (2011)	
emBRACE (Building Resilience Amongst Communities in Europe) Community Resilience Framework	Three interrelated domains: A).Resources and capacities: (5 capitals from the SLF: natural, physical/place based, financial, socio-political and human) B). Actions: civil protection and social protection C) Learnings: risk perception, problematising risk/loss, critical	68 indicators 14 core indicators Uses mostly primary data with some secondary data	Natural hazards Communities	Kruse et al. (2017) emBRACE deliverables	The framework was developed as part of the European research project Building Resilience Amongst Communities in Europe

Title of framework	Key components	Indicators/metrics (primary/secondary[4] data collection)	Resilience to what of whom/what?	Key papers	Use
	reflection, experimentation and innovation, dissemination, monitoring and review 2 extra-community processes and structures: disaster risk governance and context, change, disturbance.				Within the emBRACE project there were 5 case studies
City Resilience Index	4 categories: the health and wellbeing of individuals (people); urban systems and services (place); economy and society (organisation); and, finally, leadership and strategy (knowledge), each with 3 goals. 7 qualities of resilient cities: flexible, redundant, robust, resourceful, reflective, inclusive and integrated.	56 indicators (3 – 5 each per 12 goals) 156 prompt questions (1 – 7 per indicator) to collect both quantitative and qualitative (best and worst case scenario) data Qualitative resilience profiles from qualitative data, no overall indices computed.	Shocks and stresses Cities	Arup and Rockefeller Foundation (2015)	Tested in 5 cities in the development phase, more details at www.cityresilienceindex.org
Australian Natural Disaster Index (ANDRI)	8 themes of coping capacity: social character; economic capital; infrastructure and planning; emergency services; community capital; information and engagement	Indicators for coping capacities and adaptive capacities Secondary data collection	Natural hazards Communities	Parsons et al. (2016) Parsons et al. (2017)	Used to map resilience to Natural Hazards across Australia

Title of framework	Key components	Indicators/metrics (primary/secondary[4] data collection)	Resilience to what of whom/what?	Key papers	Use
	2 aspects of adaptive capacities: governance, policy and leadership; social and community engagement These are set within a context of hazard type and occurrence and external drivers and linkages	Aggregated measures of sub-indices and overall indices, mathematically computed			

The key similarities and differences between the frameworks are:

- Five of the six use a capitals/capacities approach, albeit in a slightly different way. This means that they are taking a multidimensional view of resilience, which includes structural resilience through to social and environmental resilience. There are overlaps in terms of the capitals/capacities approach e.g. social/human, economic/financial, environmental with some differences. Three frameworks (Flood Resilience Measurement Tool - FRMT, emBRACE and DFID Disaster Resilience Framework) draw on DFID's sustainable livelihoods framework (SLF)[5] (DFID, 2000). Two (Flood Resilience Measurement Tool, City Resilience Index) draw on the idea of qualities or properties of resilience which comes from systems approaches to resilience i.e. robustness, resourcefulness, redundancy, flexibility etc.
- In terms of scale, the frameworks are operationalised at the community (emBRACE; Community Flood Resilience Tool), city (City Resilience Index) and national scale (Australian Neural Disasters Index - ANDRI; Baseline Resilience Indicators for Communities - BRIC).
- Two approaches develop an index of resilience computationally: BRIC and ANDRI.

Indicators that have been shown, empirically, to reflect increase or decrease in levels of coping and/or adaptation to a natural hazard in the object/community/city will be more reliable and robust indicators. Cutter et al. (2010) and Parsons et al. (2016) do show clearly where there is evidence for links between the variable and levels of resilience, but this is absent from many other studies and therefore needs further verification.

Government and agency approaches to resilience in England and Wales

Moving to the definitions and frameworks used by government departments and agencies, the use of the term "resilience" varies. It is used on its own as "resilience" to something, e.g. flooding, climate change or of something, e.g. communities, infrastructure as well as in conjunction with other terms, e.g. "community resilience" (Cabinet Office - CO, 2018; Defra, 2014), "infrastructure resilience" (NIC, 2018), "flood resilience" (Defra, 2016) and "resilient places" (EA, 2019). In relation to flooding, resilience is used to refer to properties (Defra, 2016), communities (CO, 2011), infrastructure (NIC, 2018) and more generally to places (EA, 2019).

In the second workshop for the project, participants from key infrastructure providers discussed their approaches to resilience. In contrast to place based approaches, they focus on the resilience of their systems, e.g. energy, water, or telecoms. Taking a systems

[5] Cited in Global Livelihoods for People Living in Poverty paper: 'DFID's Sustainable Livelihoods Approach and its Framework' (2008). Accessed 12 January 2020: http://glopp.ch/B7/en/multimedia/B7_1_pdf2.pdf

approach means that their focus is on the parts of the system that might be most vulnerable and cause the greatest negative consequence if disrupted by an event. The goal of resilience for the system is on "keeping the lights/water/signal on".

The use of the four Rs was discussed, drawing on the Cabinet Office's report "Keeping the country running: natural hazards and infrastructure" (CO, 2011). Arcardis/United Utilities (2017) have taken those four Rs and developed an approach to a resilience metric for water treatment works which is risk based, showing the potential for an approach to resilience. In this way, resilience of the system is developed in a bottom up way by looking at the resilience of specific assets starting with water treatment works. Ultimately the suggestion is to look at a range of assets within the system.

- There is no single agreed definition or conceptualisation of resilience and its application varies, as shown in this report. Nevertheless, there are commonalities that run through them which echo aspects of the academic literature. A number of definitions (e.g. NIC, 2019; EA, 2019; CO, 2018) highlight qualities of resilience: e.g. resistance, reliability, redundancy.

- The Cabinet Office (CO) definition of what resilience is trying to achieve, i.e**. *future prosperity***, goes beyond recovering from the disruptive event which is what the other definitions focus on.

- In terms of focus and detail there is an emphasis on resilience of **infrastructure** and **emergency planning and response** which could be thought of as a focus on reactive rather than proactive resilience. The CO work on community resilience along with the Local Resilience Forum (LRF) standards of resilience, provide the most detailed practical guidance for local authorities and members of the LRFs.

- The only suggested **quantitative measurement** of resilience is expressed in probabilities. Specifically, the NIC recommends a **resilience standard**: "*The Commission's judgement is that all properties, wherever feasible, should be resilient to severe flooding, with a 0.5 per cent annual probability, by 2050".*

- There is an emphasis within the Draft National Strategy on context and the differences between places, reflecting an understanding of the multidimensionality of resilience.

- Overall, the academic work on resilience provides some clear direction on what a definition of adaptive and transformative resilience should cover. Specifically, a capacities approach expresses the multidimensionality of resilience together with qualities which provide clarity and guidance on the nature of resilience. These are building blocks for an approach to resilience.

What different metrics, indicators or standards have been used to describe, measure, assess or set targets for resilience to natural hazards, generally and flooding in particular?

Within the Quick Scoping Review, a review of metrics used to measure resilience was carried out. This covered the same frameworks that were examined in the section on concepts and definitions of the Quick Scoping Review (Appendix 1), specifically: Baseline Resilience Indicators for Communities (BRIC) (Cutter et al., 2014), Community resilience index for Norway (Shertzer et al., 2019), Flood Resilience Measurement Tool (FRMT) (Keating et al., 2017; Campbell et al., 2019), emBRACE community resilience framework (Kruse et. al., 2017), City Resilience Index (CRI) (Rockefeller Foundation/Arup, 2015); Australian Natural Disaster Index (ANDRI) (Parsons et al., 2016) and the flood hazard metrics in UK (including Neighbourhood Flood Vulnerability Index (NFVI), Social Flood Risk Index (SFRI) and Relative Economic Pain (REP) as introduced by Sayers et al. (2016)). Details of the metrics for each of these frameworks can be found in Quick Scoping Review (Appendix 1).

While all the reviewed assessment frameworks/metrics are indicator based, some apply a top down assessment and mostly use secondary data (e.g. BRIC, Community resilience index for Norway, ANDRI, NFVI). However, some apply bottom up evaluation approaches using a mix of primary (interviews, questionnaires, workshops) and secondary data sources (FRMT, emBRACE, City Resilience Index).

The geographical scale at which resilience is measured varies across the frameworks, with some focussing at the level of community or neighbourhood (e.g. emBRACE, FRMT) and some covering cities (e.g. City Resilience Index). Some aim to provide for resilience evaluation for the whole country at the level of municipality (Community resilience index for Norway, ANDRI, NFVI).

Three of the revised frameworks result in a numerical score for overall resilience (BRIC, Community resilience index for Norway, and ANDRI) and two show performance against various elements of resilience (FRMT and City Resilience Index). Two of the assessment frameworks reviewed, which are both to some extent self-assessment evaluation tools, are supported and enabled by on-line platforms (FRMT and CRI).

The evidence review shows there are numerous frameworks to measure resilience. However, Keating at al. (2017) recognise that measuring resilience is a challenging task for two reasons:

1. it is a hidden quality that is not revealed until put to the test, i.e. in a disaster or specifically a flood
2. it is often influenced by a complex set of holistic and qualitative characteristics.

These challenges are not unique to resilience measurement. Gathering, synthesising and analysing often subjective and qualitative narratives is becoming a core part of modern development monitoring and evaluation (M&E) practice (Keating at al., 2017). Some

common theoretical and practical challenges for indicator-based resilience measurement frameworks summarised from Keating et al. (2017) are:

- defining an appropriate scale of analysis both geographically and temporally including specifying boundaries (“resilience of what to what?”)
- identifying the potential end users (“indicators for whom?”) and potential purposes (“indicators for what?”)
- balancing the need for specific indicators (to a particular hazard in a particular place for a particular institution) and the need for wide applicability.

Although many question whether an unclear concept like resilience can be measured, practitioners and academics increasingly highlight the value of having resilience measures to manage natural hazard risks (Burton, 2015; Cutter, 2016). They emphasise that without a quantitative resilience assessment, it is not possible to compare entities (e.g. areas, countries, etc.), to monitor performance, or to identify strengths and weaknesses in the system to improve the trajectory towards resilience (Scherzer et al., 2019). The top-down metrics (NFVI, SFRI and REP) developed by Sayers et al (2016) provide a basis for this kind of assessment in the UK.

FRMT, CRI and emBRACE provide examples of the value of using bottom-up primary data to develop a better understanding of the resilience of places. It would be useful to develop consistent methods for this kind of measurement to be included as part of a set of resilience monitoring and evaluation tools.

As argued by Tanner et al. (2017), who reviewed challenges for resilience policy and practice, the interpretation and definition of resilience is so unclear that measurement becomes contested and a major challenge. Tanner et al. (2017) summarise 12 main challenges for monitoring, evaluation and learning around resilience as follows:

- Integration - Integrating resilience measurement into standard workflows of ongoing programmes, and not keeping them as separate M&E processes.
- Spatial levels - Linking evidence and building processes from local to national levels that inform, advise and guide resilience-building investments.
- Complexity - Addressing the issue of complex systems in M&E through connecting people who are working on innovative evaluation approaches and methods with a focus on resilience.
- Common frameworks and tools - Creating commonly accepted frameworks, tools and databases to systematically generate and store evidence on resilience.
- Power and gender - Incorporating issues of vulnerability, power and gender effectively into resilience measurements.
- Large-scale investments - Establishing M&E for programme-level, large-scale investments.
- National capacity - Building capacity of M&E practitioners in the field, for building and strengthening the pipeline.

- Measurement of transformation - Bringing in effective methods for measurement of transformative capacity at levels above community, making more of the data collected, and supporting more cross-fertilisation, maybe around common strategic goals.
- Systems-level measures - Developing systems-level indicators that measure capacities (anticipatory, adaptive and transformative) at scales greater than the household (e.g. cities).
- Capacity to track large-scale changes - Applying capacities to larger scales and measuring capacities at levels higher than household scale to determine applicability and to track changes.
- Systems-level resilience - Bringing in data and measurement techniques that can help capture systems-level resilience, rather than simple households (noting that 'simple' is a misnomer).
- Indicators of systems-level resilience - Defining common indicators of resilience capacity and resilience outcomes at system, rather than individual, levels.

How the identified resilience frameworks (both concepts and metrics) perform against FCERM criteria

Four of the frameworks reviewed (FRMT, CRI[6], ANDRI, BRIC[7]) were selected for detailed assessment. These were chosen to represent different approaches: for example, ANDRI is a top-down national approach focusing on wider disaster resilience, CRI is a bottom-up approach focusing on wider disaster resilience at the city level and FRMT is a bottom-up approach focusing on flood resilience. The BRIC is also more top down but has a more local focus than the ANDRI and emphasises communities. All four focus on flood or disaster resilience and have been empirically tested; each has the key components of a resilience framework:

- Clear **definition** of adaptive, transformative resilience
- **Multidimensional approach** to resilience: physical, social etc.
- Well defined **indicators**
- **Metrics**

The four frameworks were qualitatively assessed against criteria outlined in Defra's original project specification which included:

[6] Initially the emBRACE Community Resilience Framework was assessed, however following further consideration from experts involved in the project, the City Resilience Index was later evaluated against the FCERM characteristics as well as presented in the workshops instead and is presented in Table 3.

[7] The Baseline Resilience Indicators for Communities (BRIC) (Cutter et al, 2014) was included after the QSR was completed because it is a framework that has been used in the evaluation of the Defra Flood Resilience Community Pathfinders and more recently by the Environment Agency (Environment Agency, 2019b).

- Can be tailored to geographical area and local variation
- Level of ambition to drive action
- Distribution of costs and benefits
- Communication: meaningful to a range of audiences
- Timescales: enables identification of timescale for implementation (short- to long-term)
- Appropriate and feasible allocation of roles and responsibilities
- Feasibility and affordability of data collection and verification

Error! Reference source not found. presents a summary of the assessment of the frameworks against these FCERM criteria. It focuses on the operationalisation of resilience frameworks; it does not assess the effectiveness of the frameworks in achieving their own purposes or in contributing to the enhancement of resilience more widely.

We have used a simple High (H/ green) – Medium (M/ amber) – Low (L/ red) scale, to reflect the high level nature of these scores, based on the literature examined rather than an extensive examination of each of the frameworks. Not applicable (N/A) is used as needed. We have made the assumption that any data collection and verification system will have to cover a range of characteristics, qualities and outcomes. Judgement about feasibility and affordability are based on the kinds of data which would need to be collected (i.e. does the data already exist; if the data does not exist, can it be collected easily by non-specialists; can indicators be selected to reflect differences in context).

Table 3: Frameworks assessment against the FCERM criteria

Key: H = Fully meets or has the potential to fully meet the criterion; M= Meets part but not all the criterion; L= Does not meet the criterion or meets only a limited part

Criteria	Frameworks			
	Flood Resilience Measurement Tool/ FRMT (Zurich Flood Resilience Alliance - Keating et al., 2017; Campbell et al., 2019)	**City Resilience Index (Rockefeller Foundation/Arup, 2015)**	**Australian Natural Disaster Resilience Index/ ANDRI (Parsons et al., 2016, 2017)**	**Baseline Resilience Indicators for Communities (Cutter et al, 2014; Burton, 2015; Scherzer et al, 2019)**
Range of risks and impacts: can be tailored to geographical area/local variation	**H**	**H**	**M**	**M**
Level of ambition to drive action	**H**	**H**	**M**	**L**
Distribution of costs and benefits	**N/A**	**N/A**	**N/A**	**N/A**
Communication: meaningful to a range of audiences	**H**	**H**	**M**	**M**
Timescales: enables identification of timescale for implementation (short- to long-term)	**N/A**	**N/A**	**N/A**	**N/A**
Appropriate and feasible allocation of roles and responsibilities	**H**	**H**	**L**	**L**
Feasibility and affordability of data collection and verification	**M**	**H**	**H**	**H**

How these resilience frameworks are used

The frameworks reviewed are used to:

- **set targets/ goals/ objectives and measure change.** FRMT and City Resilience Index are to some extent bottom-up self-assessment evaluation tools, enabling

cities and communities to establish a baseline/ benchmark and measure disaster resilience over time. ANDRI is a top-down nationally-standardised assessment of disaster resilience in Australia at one point in time, which could be used as a benchmark to monitor change in resilience at national level at a second point in time. BRIC provides a set of top-down baseline resilience indicators.

- **support communities to enhance their resilience and well-being by adapting successfully to environmental changes**. FRMT in particular stresses that the goal of resilience is to enhance wellbeing rather than simply to manage disaster risks more effectively.
- **compare levels of resilience in different places / geographically.** ANDRI is intended to provide a comparison of levels of disaster resilience across Australia, with municipalities being the smallest units of comparison. BRIC is more locally focused with the emphasis on communities. FRMT also enables the comparison of performance between different areas.
- **inform policies and decision-making.** City Resilience Index is intended to provide data to inform cities' urban planning and investment decisions, ANDRI was developed to help inform the management of natural hazards at the national scale, and it is hoped that FRMT will deepen understanding of disaster resilience in order to better target initiatives to enhance resilience.
- **target measures, actions and 'elements' of frameworks (i.e. capacities and qualities).** All four frameworks, but in particular the City Resilience Index and FRMT, can be used to identify and target measures, actions and elements of the frameworks (e.g. capitals - human, social, or financial etc.; or qualities - robustness, resourcefulness, rapidity etc.) that have been most successful in enhancing resilience as well as the ones that need more attention and improvement.

A brief summary of the use of the four frameworks assessed is shown below. The frameworks are described in more detail in the Quick Scoping Review (Appendix 1).

Flood Resilience Measurement Tool (FRMT)

FRMT is a holistic tool developed by Zurich Flood Resilience Alliance to 'test and validate a measure of community flood resilience' (Campbell et al., 2019, p.1). As presented in Table 2, a web and mobile based tool was developed to measure 88 sources of community flood resilience (e.g. flood exposure perception, first aid knowledge, household flood insurance etc.) related to the five capitals ('5Cs'), i.e. Human, Social, Natural, Physical and Financial capital. Between them they were chosen to represent the qualities or properties of resilience ('4Rs': Robustness, Resourcefulness, Rapidity and Redundancy) together with the different stages of the flood disaster cycle (i.e. Prospective risk reduction; Corrective risk reduction; Crisis preparedness; and Coping). This is the only framework reviewed that also measures resilient ex-post flood outcomes (e.g. death and injury due to flooding, property and building loss and damage, flood learning, insurance action etc.) (Keating et al., 2017). These outcome measures could provide options for developing targets for changes in resilience levels.

Data collection is supported by a web-based and mobile device platform and is carried out every two years using one or more of five data collection methods (household survey, community focus group discussion, key informant interviews, interest group discussion and third-party data). The collection methods are selected by the users who are trained practitioners (largely international development NGO staff) working in developing countries.

The data collected is then used by designated community and NGO expert assessors to allocate a score from A to D (A being the best and D being the worst) for each of the 88 sources of resilience. Grade results (presented numerically) are displayed according to the 5Cs framework as well as other categories (dimensions) to inform a discussion on how to identify potential measures for building resilience.

City Resilience Index

The City Resilience Framework developed by the Rockefeller Foundation and Arup (2015) provides the basis for the City Resilience Index, by defining its structure, categories, goals and indicators. The index comprises 12 goals (the elements that are most important in case of disastrous or catastrophic events) related to four dimensions of every city (health and wellbeing, economy and society, infrastructure and environment, and leadership and strategy), 52 indicators and 156 variables (i.e. qualitative questions and quantitative metrics). The aim of the index is to '*provide a common basis of measurement and assessment to better facilitate dialogue and knowledge-sharing between cities'* (Rockefeller Foundation / Arup, undated, p.8). As stated by the authors, it '*will provide cities with a comprehensive, credible, and technically-robust means to assess and monitor their resilience in order to inform urban planning and investment decisions*' (Rockefeller Foundation / Arup, undated, p.28). The index is intended to assess and measure relative performance of cities over time (i.e. the extent to which the city is achieving the 12 goals, based on 52 indicators), rather than comparing them to each other, so it does not deliver an overall score or provide a world ranking of the most resilient cities.

As a self-assessment tool, cities use the Index to identify and understand what they are already doing (their strengths and weaknesses) to improve their resilience performance, and their trajectory. It is generally not possible to provide a quantitative measure of future performance therefore the index gathers qualitative data to help indicate the city's resilience path. This evaluation process involves the city planning their own performance (and actions) against each sub-indicator, using a series of qualitative questions. Cities assign a quantitative score on a linear scale from 1 to 5 based on a definition of what the worst (1) and best (5) performance could look like.

Where possible, cities can also measure their current performance using quantitative data based on proxy measurements within each sub-indicator. This enables cities to establish a baseline, identify elements that might need attention to improve their resilience profile, compare performance between areas and monitor performance over time.

Like the FRMT (Campbell et al., 2019), the index application is enabled and supported by an online 'self- assessment' platform, which is used by city governments for collecting and analysing data and creating their city's resilience profile.

Australian Natural Disaster Resilience Index (ANDRI)

The ANDRI (Parsons et al., 2016) adopts a top-down approach, applying indicators obtained from secondary data on a national scale. It is a hierarchical design based on six themes of coping capacity (i.e. social capital; economic capital; infrastructure and planning; emergency services; community capital; information and engagement) and two themes of adaptive capacity (i.e. governance, policy and leadership; community and social capital).

The aim of the ANDRI is to assess the state of disaster resilience in Australia at one point in time and not to evaluate regulated performance criteria. The outcome is a 'nationally-standardised assessment of disaster resilience in Australia', reported as a State of Disaster Resilience Report.

The level of detail of the data used for the assessment is, where possible, the Statistical Area 2 (SA2) level of the Australian Bureau of Statistics as it is most illustrative of Australian neighbourhoods/suburbs and is the smallest level of the Australian Statistical Geographical Standard for which essential statistics (e.g. population, health, etc.) are all available.

ANDRI produces an aggregate score building up from the sub-themes, through the themes, using statistical methods. This has made it possible to produce a "state of disaster resilience" map for Australia, based on the index (Parsons et al., 2017).

Disaster resilience of place (DROP) model and the baseline resilience indicators for communities (BRIC)

These two approaches have been developed by Cutter and colleagues. The DROP model (Cutter et al., 2008) proposes that there are two types of resilience: inherent resilience, or the capacities within a community or system that can be drawn on to help cope with an event or crisis, and adaptive resilience, which is developed during or as result of the event or crisis. The model includes six capacities: social, economic, housing/infrastructure, institutional, community and environment/ecological. There are a small number of indicators for each capacity to enable the measurement of baseline resilience. This has been undertaken for areas of the US (Cutter et al., 2014), post-Katrina (Burton, 2015) and in Norway (Scherzer et al., 2019).

For this baseline assessment work, data is collected from secondary sources. The benefit of using existing data is that it has already been validated and a national dataset will be consistently available. The downside of using such data is that it is often at different scales and not always fine grained enough to enable differentiation of places' resilience.

Cutter et al. (2014) developed Baseline Resilience Indicators for Communities (BRIC) building on the DROP model. BRIC provides a composite index of community resilience to disasters. This is done by summing the composites of the six resilience sub-indexes. Potential scores range from zero to six, with higher scores corresponding to more resilience, and lower scores, less resilience. BRIC values can then be compared over time (e.g. 2000, 2005, 2010, etc.) as a means for charting progress in enhancing resilience to disasters.

Discussion and recommendations for going forward

This section proposes an approach to flood and coastal erosion resilience for England and Wales, identifies its potential objectives and discusses the resilience capacities and qualities that the approach would encourage.

A proposed approach to flood and coastal erosion resilience in England and Wales

We suggest that an approach to resilience consists of having a clear definition and set of component parts. This will enable a common language to develop and avoid misunderstandings. Once this is in place, it should be possible to map out what will be needed.

Here we outline the component parts of a definition underpinned by an approach to setting goals and describing resilience capacities and qualities.

Defining flood and coastal erosion resilience

As discussed in the previous section, there is broad consensus that **definitions** should cover the ability or capacity to **prepare for, respond to, recover from** and **adapt to** damaging hazard events.

Further, protection is captured within the qualities of resilience as resistance, robustness or absorption, rather than being part of a definition of resilience. However, depending on the emphasis felt to be important, it could remain within the set of qualities or be more prominent within a definition e.g. after Cutter (2016) who uses the term "absorb":

"*This paper takes **a broad definition of disaster resilience to infer the ability to prepare and plan for, absorb, recover from or more successfully adapt to actual or potential adverse events (NRC 2012).** This definition can be applied to many different study units ranging from individual (people, structure), to group (social units such as households or social groups), or systems (infrastructure, sectors). It also has a geographic scale dimension ranging from the local neighborhood, to communities, to cities, to counties, and to nations.*" Cutter (2016, p.742, our emphases)

Many definitions also include **transformation**, highlighting the need to consider complete system change in the face of hazardous events. A clear distinction can be made between those definitions that focus on the ability of a place to flourish and those that thrive in spite of hazardous events:

*"the ability of a **system, community, or society** to pursue its social, ecological, and economic development and growth objectives, while managing its disaster risk over time in*

a mutually reinforcing way. Central to this conceptualization are the key community capitals……. This conceptualization is centred on ***enhancing wellbeing*** *as the goal of resilience, rather than* ***disaster risk management****, which can be a means to resilience".* *(*Keating et al., 2017, p.78, our emphases*)*

There are also definitions which focus more on dealing with the hazard in order to maintain functioning and the capacity to learn:

"The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation". (IPCC, 2014, p.127)

We suggest that any definition takes account of the broader goal of resilience which is about people, places and the environment thriving and flourishing in the context of flooding and coastal erosion. The Cabinet Office definition of community resilience has a focus on both emergencies (including floods) and on the wider aspects of thriving and flourishing:

"Community resilience is enabled when the public are empowered to harness local resources and expertise to help themselves and their communities to:

- *prepare, respond and recover from disruptive challenges, in a way that complements the activity of Category 1 and 2 emergency responders;*
- *plan and adapt to long term social and environmental changes to ensure their future prosperity and resilience."* (CO, 2019, p.2)

Further, definitions often use the terms "community" and/or "place". The concept of communities has long been debated and what is clear is that a community can never be satisfactorily defined solely by location or by its networks. Ultimately, it can mean different things to different people. We understand it to be a combination of spatial, social and cognitive elements. This means that whilst communities are located in places, they cannot be taken as synonymous with that place.

Understanding how the networks and identities function in a place is a key part of building resilience in the same way as understanding how the physical place functions. We suggest that both terms are used in any definition going forward to mark that distinction.

Definitions set the direction and emphasis of resilience. Ultimately, they can be translated into goals such as reduction in physical damage, speed of recovery, reduction in mental health effects, improved feelings of communities being able to live with floods etc.

Based on the above it can be argued that a progressive definition of flood and coastal resilience:

- emphasises learning and adaptation alongside protection, response, and recovery
- makes a clear differentiation between community and place

- unpacks capacities to cover all aspects of systems (e.g. social, economic, institutional, infrastructure, community capital and environmental)
- highlights the maintenance of identity and functions of places and communities embedded within a wider narrative of thriving and flourishing in spite of floods and coastal erosion.

Identification of potential goals for flood and coastal erosion resilience in England and Wales

As discussed above, the definition of resilience sets a direction of travel. To measure resilience one first needs to establish a baseline which is an evaluation (a snapshot) of resilience in at a certain point in time. The baseline is a reference point against which one can measure the flood and costal erosion resilience performance. The move towards "increasing flood and coastal erosion resilience" from "reducing flood and coastal erosion risk" reflects the need to diversify FCERM approaches to live well in spite of floods. There is also a need to acknowledge that the contexts of places and communities that interact with FCERM approaches themselves contribute to create resilient pathways. There then needs to be a consideration of how the definition might translate into goals for flood resilience in England; and also how these goals translate into standards or targets.

Coming from our discussion of definitions of resilience the following are possible goals that could be discussed in the context of FCERM in England and Wales. These are not intended to be exhaustive:

1. Maintaining:
    - the identity of communities and places
    - the functions of communities and places
    - livelihoods in communities and places
2. Supporting and encouraging
    - the most vulnerable in communities
    - the reduction of disadvantage and inequity in and between communities
3. Protecting and enhancing
    - the health and well-being of communities and places
    - the existing wealth and prosperity of communities
4. Stimulating
    - appropriately high levels of flood risk awareness, memory and knowledge of local environmental changes
    - consideration of appropriate and timely adaptation
    - appropriate adaptive responses

These goals are all in the context of strategies and policies wider than FCERM and are designed to help keep in mind the overall goals of FCERM which focus on creating and maintaining a prosperous and healthy society. To support these wider goals there is a need for more second order focussed measures. For example, such as those described in

the FRMT (Keating et al., 2017). They identified 29 ex-post outcome measures which are yet to be fully operationalised (see **Error! Reference source not found.**).

Box 2: Keating et al. (2017) Ex post outcome measures

Keating et al.'s (2017) list of ex-post outcome measures for floods. These were developed through reviewing evidence, reviewing standard practice in flood impact assessment and stakeholder validation.

Death and injury due to flooding
Building losses and damage
Property losses and damage
Prevalence of post-flood illness
Health care provision
Education provision
Income stability
Business interruption
Food security
Communications infrastructure
Road and transportation infrastructure
Clean water
Sanitation
Waste disposal
Electricity
Social cohesion
Property crime and looting
Natural environment
Flood learning
Early warning system function
Preparatory actions
External flood assistance
Legal and regulatory constraints
Selling assets
Risky livelihoods
Insurance
Flood frequency and severity
Number of people impacted
Flood duration

These could be used to elaborate the goals for flood resilience in England, many of which already are reported on, but do not currently have standards or targets for example:

- Death and injury due to flooding
- Building losses and damage
- Property losses and damage
- Flood learning
- Early warning system function
- Insurance action
- Flood frequency and severity
- Number of people impacted

Currently, there is a government commitment in relation to the number of homes to be protected. The government committed £2.6 billion in total between 2015- 2021, to better protect 300,000 homes by this date. Further, the NIC (2018) has recommended setting a nationwide standard of resilience to flooding with an annual likelihood of 0.5% by 2050 where this is feasible and a higher standard of 0.1% for densely populated areas where the costs per household are lower.

Both of these relate to protection so reflect only one aspect of resilience. If a multidimensional approach to resilience, covering learning and adaptation alongside

protection, response, and recovery is to be implemented, any targets or standards should reflect all these aspects of resilience.

Resilience capacities

As discussed earlier, a range of capacities or capitals can be discerned within the literature which support/inhibit resilience of places and communities. There are a number of different framings of these capacities and we would suggest that Defra and the EA have further discussion around which would be most appropriate given that previous work (e.g. Twigger-Ross et al., 2015) has built upon the Cutter et al.'s (2010) Baseline Resilience Indicators for Communities framework and ongoing initiatives within the EA (Environment Agency, 2019a) have further developed the BRIC framework. We suggest that it has an intuitive appeal given the set of capacities and importantly, it includes environmental capacity, although this was not used within the Flood Community Resilience Pathfinders evaluation (Twigger-Ross et al., 2015).

However, we also think that the Parsons et al. (2016) Australian Natural Disaster Resilience Index has much to offer, partly because it captures the two key aspects, coping capacity and adaptive capacity that should be part of any definition, as shown in **Error! Reference source not found.**.

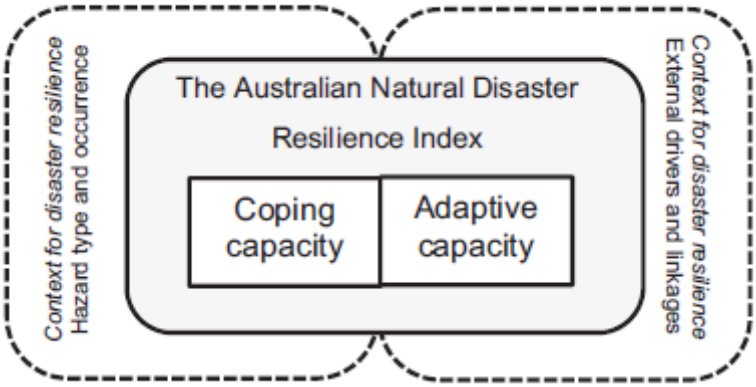

Fig.1 Australian National Disaster Resilience Index

Table 4 provides a comparison of the two approaches to capacities. What can be seen is that they map quite well onto each other, and indeed reflect the general categories in Cutter's (2016) review of 27 different resilience assessment tools, indices and scorecards.

Table 4: Capacities for resilience

Capacities		Description of capacity
ANDRI capacity definitions	BRIC capacity definitions	
Coping capacity	**Capacity (inherent and adaptive)**	
Social character – the social characteristics of the community (SC)	Social resilience – the current and potential capability of individuals to engage with flooding within a community	Represents the social and demographic factors that influence the ability to prepare for and recover from a flood. For example, "*communities with fewer elderly, disabled residents, and non-native speaking residents likely exhibit greater resilience than places without these characteristics*" (Cutter et al., 2010, p.8)
Economic capital – economic characteristics of the community (EC)	Economic resilience - the economic vitality of both individuals and the community, including housing capital and ownership, equitable incomes, employment and business sustainability	Represents the economic factors at both the individual and community level that influence the ability to prepare for and recover from a flood
Infrastructure and planning – the presence of legislation, plans, structures or codes to protect infrastructure (IP)	Infrastructure resilience – "*mainly an appraisal of community response and recovery capacity and the extent to which physical infrastructures that house, transport and produce goods and services for society may be particularly vulnerable to sustaining damage and likely economic losses" (*Cutter et al., 2010, p.9)	Represents preparation for natural hazard events using strategies of mitigation or planning or risk management. For Cutter et al. (2010) this focuses more on the physical infrastructure. Twigger-Ross et al. (2015) extend this further to mean physical measures taken by the community and individuals to improve their resilience e.g. PFR. It should also include larger flood defences.
Community capital – the cohesion and connectedness of the community (CC)	Community capital - the sense of community, place attachment and citizen participation	Represents the features of a community that facilitate coordination and cooperation for mutual benefit in relation

Capacities		Description of capacity
		to FCERM. It also includes social identities that exist within groups and networks.
Emergency services – the presence of emergency services and flood response plans (ES)	Institutional resilience (inherent) – the relationships between the formal institutions and informal institutions in the provision of emergency services.	Represents the potential to respond to a flood
Information and engagement – availability and accessibility of flooding and community engagement to encourage risk awareness (IE)	Institutional resilience (inherent) – relationship between informal and formal institutions are mediated by knowledge	Represents the relationship between communities and information, the uptake of information about risks and the knowledge required for preparation and self-reliance.
	Environmental resilience	Represents the qualities of the environment that enhance absorptive capacity of coastal surges and freshwater flooding together with the efficiency with which a community uses natural resources.
Adaptive capacity		
Governance, policy and leadership – the capacity within government agencies to learn adapt and transform (GPL)	Institutional (adaptive) – development of organisations and their relationships with informal structures.	Represents the flexibility within organisations to adaptively learn, review and adjust policies and procedures or to transform organisational practices. Cutter et al. (2010) put less emphasis on this aspect but it is key to increased resilience.
Social and community engagement – the capacity within communities to learn adapt and transform (SCE)	Community capital (adaptive) - the sense of community, place attachment and citizen participation	Represents the social enablers within communities for engagement learning adaptation and transformation.

These capacities have been chosen by both Parsons et al. (2016) and Cutter et al. (2010) because there has been research to show the relationships between them and increased/decreased resilience of a community in place.

What is clear is that some of these capacities are general yet influence resilience to flooding e.g.:

- Social resilience - health of residents – people with poorer health are likely to take longer to recover from a flood;
- Economic capital – low incomes – people on low incomes are less likely to have insurance or to have surplus funds to help in their recovery.

These capacities need to be understood by risk management authorities (RMAs) (e.g. the Environment Agency and local authorities) because they will affect response, recovery and planning and will alter the strategies taken by the RMAs in their resilience planning. However, improving these types of capacities is not the direct responsibility of an RMA. It does add another layer of complexity and challenge in helping communities to become more resilient to flooding. There are capacities, e.g. poor health, that are better understood by agencies other than the RMAs, which strengthens the case for cross sectoral working on resilience.

However some capacities have a direct relationship with flooding and coastal erosion e.g.:

- Information and engagement – flood warnings: having a flood warning increases the likelihood of reduced damages from a flood.
- Infrastructure and planning: flood defences and natural flood management reduce the likelihood of floods.

These are the capacities on which most of the work of the RMAs is currently focussed. Indeed, the Draft National FCERM Strategy's concept of Resilient Places draws out the capacities that the Strategy seeks to develop through its different "tools" or interventions:

"Resilience in places should be made up of a combination of tools that reduce the likelihood and consequence of flooding. These tools include: ***asset resilience*** *(delivering a standard of protection through construction of new defences and maintenance of existing defences),* ***catchment solutions*** *(e.g. natural flood management) and community or business resilience measures (e.g.* ***property level resilience, warnings and recovery plans****)."* (EA, 2019, p.62)

It is important to note that these capacities vary in their ability to change quickly. For example:

- Community capital – networks to support flood resilience behaviours take time to develop especially if existing networks don't exist
- Governance, policy and leadership - organisational procedures can change relatively quickly.

Finally, some of these capacities can be "controlled" or "managed" e.g. by single organisations such as Defra, the Environment Agency, etc. e.g. coverage of flood warnings, flood defences. Others will need partnerships across a number of organisations e.g. emergency planning involves the Environment Agency, emergency services and other

local authority services. Finally, some are systemic, e.g. economic deprivation. These are slow to change and governed by both local and national (even global) trends.

Thinking about capacities is useful because it:

- enables resilience strategies to be holistic, and makes it possible for one capacity to compensate for the lack of another e.g. strong social networks enabling an early response to a hazard in a remote area
- enables resilience to a specific hazard (e.g. flood) to be embedded into a wider framework of resilience and an understanding of interactions with general aspects that affect resilience
- enables a systematic approach to resilience, so that different organisations dealing with different capacities/resources can be fitted into the same framework as each other
- enables a portfolio of measure/strategies to be deployed in order to improve resilience
- facilitates the use of a common language
- enables measurement and metrics to establish baselines and to evaluate interventions.

Resilience qualities

A number of frameworks describe qualities of resilient systems as discussed earlier in this section. We suggest that the four from the Zurich Floor Resilience Alliance FRMT (Keating et al., 2017) are considered as part of the approach to flood and coastal erosion resilience.

Box 3: Examples of resilience qualities

Redundancy is the extent to which alternative elements, systems, or other measures exist that are substitutable, i.e. capable of satisfying functional requirements in the event of disruption, degradation, or loss of functionality.

Resourcefulness is the capacity to identify problems, establish priorities, and mobilize alternative external resources when conditions exist that threaten to disrupt some element, system, or other measure. Resourcefulness can be further conceptualized as consisting of the ability to apply material (i.e. monetary, physical, technological, and informational) and human resources in the process of recovery to meet established priorities and achieve goals.

Rapidity is the capacity to meet priorities and achieve goals in a timely manner in order to contain losses, recover functionality, and avoid future disruption. Rapidity takes account of learning and recovering in a more resilient way, which may involve a transformation. While it is mostly an ex post property of resilience, investments made ex ante can create rapidity ex post.

Robustness is strength, or the ability of elements, systems, given level of stress or demand, without suffering degradation or loss of function.

As with a definition, qualities provide direction and something to use to interrogate interventions designed to improve capacities/resources. A structure or institution could be assessed against these qualities for example: how resourceful is a local authority in the face of a flood? how much stress can a flood defence stand up to before it is overwhelmed? It allows a qualitative assessment of capacities ("Is there enough?") to complement the quantitative ("What is the type?"). That is, as well as asking how many social networks there are in a local area, it might be asked whether there is any redundancy in those networks e.g. if everyone in the network gets flooded can the community flood warnings be given out by other people. The community will be more resilient if the answer is yes.

Resilient qualities are regarded as essential aspects of a resilient system. Keating et al. (2017) suggest they can help to determine why one community may recover better from a flood than another, as they provide evidence about the nature of the resilience capacities present. For example, a community may have an active network of flood volunteers. However, if it relies on one key member who is flooded and is not able to contact other volunteers, then that network is not robust and doesn't have any redundancy in it. Having some substitutability in the network will improve the resilience of that community. Knowing that there is a network of flood volunteers in a place is a start to understanding the resilience of that community but knowing how far that capacity has resilient qualities will provide a more accurate assessment of the level of resilience.

An example of how a focus on the resilience quality of robustness is important is having a flood defence which provides protection from flooding, but if that defence is not robust and reliable because of a lack of maintenance it could fail and reduce the resilience of the place.

Other examples of the value of focussing on resilience qualities are ensuring that an emergency team is able to be resourceful during an event through planning and exercising the plans in scenarios with surprises. Or designing an electricity system so that if one area fails there is enough redundancy in the system that there are other routes to ensuring the lights stay on.

Essentially, each part of the system needs to be resilient and the qualities can be used to assess the extent of that resilience. The work on asset resilience carried out for this project starts to do that by investigating how asset resilience might be measured. Within the water sector for example, Arcadis and United Utilities (Arcadis/UU, 2017) have produced an approach to measuring resilience based on the four qualities from the 2011 Cabinet Office guidance on natural hazards and infrastructure: Resistance, Reliability, Redundancy, Response & Recovery.

Summary of suggested approach

The proposed approach to flood and coastal erosion resilience:

- emphasises preparing, planning, protecting, responding, recovering and adapting;

- clearly differentiates between community and place;
- unpacks capacities to cover all aspects of systems (e.g. social, economic, institutional, infrastructure, community capital and environmental);
- acknowledges inherent and emergent resilience;
- highlights the maintenance of identity and functions of places and communities;
- is embedded within a wider narrative of thriving and flourishing in spite of floods and coastal erosion;
- uses the four Rs (redundancy, resourcefulness, rapidity and robustness) to interrogate the quality of capacities/interventions;
- focuses on a wide portfolio of structural and non-structural measures to achieve its goals.

We suggest this represents a clear move towards transformative proactive flood and coastal erosion resilience.

Operationalising this approach will involve:

a. Establishing a baseline of resilience – unless what is already in place is clearly known, assessed and monitored going forward, it is difficult to know where interventions to build resilience are best placed and what types of interventions are most appropriate. This baseline data would be collected in relation to the resilience capacities, qualities and goals.

b. Having a clear portfolio of measures/interventions that verifiably reduce the risk of physical and psychological impacts of flooding and enable places and communities to live their lives well. Designing interventions to improve resilience capacities and qualities.

c. Evaluating, monitoring and learning from implementation of interventions - having clear processes of monitoring and evaluating of the effectiveness of combinations of measures to ensure a process of continuous learning and improvement for all involved in FCERM.

How public bodies and services contribute to flood resilience

Many government departments have roles in flood resilience. Some have a geographical focus on resilience of place while others focus on systems resilience, for example ensuring the maintenance of critical services like the electricity or transport networks.

The Cabinet Office has a central role in identifying risks through the National Risk Register of Civil Emergencies and Sector Security and Resilience Plans (SSRPs) (Cabinet Office, 2017), by providing guidance for planning and preparation for emergencies and coordinating emergency response at a national level.

This section provides a summary of how resilience is used by other Government departments and public bodies. This is clustered according to four areas of activity:

1. Emergency preparation and response
2. Liaison with service providers to encourage their resilience
3. Local resilience
4. Strategic thinking and planning for resilience

Emergency preparation and response

- The Civil Contingencies Secretariat (CCS) at the Cabinet Office has a central role in identifying, assessing and preparing for current and future risks, including flooding. It provides a national response to major crises (COBRA meetings) and liaises with other government departments and Local Resilience Forums.

- Ministry of Housing, Communities and Local Government has a recovery team and resilience advisors who provide advice and support for resilience and recovery to local authorities across the country. They also share information across Whitehall.

- Public Health England (PHE) considers resilience to involve anticipation, response and adaptation to shocks and stress. While the health sector has an emergency response function, its focus is increasingly on adapting and putting in place adaptive capacities. PHE engages with communities and disseminates knowledge to the public.

Liaison with service providers to encourage their resilience

- Department for Digital, Culture, Media & Sport is responsible for the digital economy. It liaises with the CCS and across government departments; it works closely with the telecoms sector to encourage the resilience of telecoms systems.

- Department for Transport (DfT) is responsible for encouraging and advising the transport industry on resilience in order to promote the resilience of transport systems; it also helps in major incidents if required.

- The Water Act 2014 gave Ofwat responsibility for furthering the long-term resilience of water and wastewater systems and service provision in England and Wales, recognising that water services are facing increasing external stresses, such as environmental pressures. Ofwat uses its regulatory powers to promote long-term planning and investment, and uses a range of measures to manage water resources sustainably (Ofwat, 2017). Water companies have been moving from a focus on operational resilience (emergency response) to a more holistic view of resilience over the recent years. They are also interested in how the resilience of the water sector can be affected by interactions with other sectors, for example the knock-on effects of the impacts of flooding on energy or communications networks.

Local resilience

- Local authorities bring together teams working in different sectors (e.g. transport, social services, health and wellbeing, etc.). Coordinating a holistic approach to resilience can be challenging as sectors have different definitions and priorities. The main priorities tend to be operational and shorter-term: assuring business continuity and running critical services (e.g. hospitals, police stations etc.)

- Local authorities are often engaged in multiple activities and initiatives related to resilience: working as part of local resilience forums, maintaining a local risk register, reviewing standards for major developments (e.g. for drainage) in the light of climate change projections, practical work with communities - e.g. Defra's flood resilience pathfinders (2013-15). Their close work with communities has for example resulted in more emergency wardens.

- Local authorities recognise the need to embed the concept of resilience in decision making to ensure long-term resilience.

Strategic thinking and planning for resilience

- The National Infrastructure Commission was set up to provide independent strategic thinking, analysis and advice to address the UK's long-term infrastructure needs. NIC conducts research on infrastructure resilience in the digital, power, transport and water sectors among others. They look at the architecture of infrastructure systems and how these systems respond to hazards like flooding.

- National Adaptation Programme in Defra contributes to the UK's Climate Change Risk Assessment (every five years) and promotes the public sector's statutory climate adaptation response. The National Adaptation Programme includes multiple measures related to flooding. The National Adaptation Programme uses the terms 'resilience and 'adaptation' fairly interchangeably, although adaptation is understood as being more long term.

- Department for International Development (DfID) looks at the ability of the UK to respond to various shocks, including climate change, with a focus on adaptation, including adaptation to flooding. DfID works on major programmes on resilience and building resilient systems in developing countries.

Based on discussions with stakeholders at the two project workshops, some of the challenges for embedding resilience across the four types of activity described above include:

- Local decision-makers need to juggle many different priorities
- There is a lack of evidence about which flood resilience measures work well and in what combinations on the ground
- There is a need to scale up evidence from local to national level
- Time and resources are needed to create new ways of working and new forms of community infrastructure, e.g. flood warden teams

- Uncertainties exist over what resilience looks like because of rapidly changing technologies (e.g. in the telecommunications sector) and changing projections of future coastal erosion and flood risk.

There is appetite among most of the organisational stakeholders who contributed to the workshops to see a clear approach to flood and coastal erosion resilience from Defra and the EA which would help actors in different sectors take appropriate decisions and actions to embed resilience.

However, this overall welcome for a national flood and coastal erosion resilience approach has caveats:

- Different resilience measures will be needed for different contexts: it will be important to have a toolkit of measures to draw on.
- At a local level, resilience building should start from existing capacities. It is important to check what is already in place before deciding what further measures should be taken. Community members and organisations are vital sources of information.
- Acknowledge the uncertainties with respect to the effectiveness of many flood resilience measures: implement a clear monitoring system to develop data on effectiveness.
- Work with infrastructure and service providers to understand dependencies between networks and resilience at different scales.

Using the proposed flood resilience approach in relation to current FCERM

This section looks at the aspects of the current FCERM system that would need to change for a flood resilience approach to be implemented. It provides an example of the way that changes in the approach to calculating the benefits of capacities and of community based and non-structural FCERM measures could be used to account for inherent resilience within communities.

The term resilience has become more prominent in flood and coastal erosion risk management in England and Wales in recent years as noted in our introduction and evidence review. However, the concept of managing consequences and taking a 'whole portfolio' approach to the measures used in FCERM has been around for much longer, at least since the then government's Making Space for Water document in 2004.

We would suggest that resilience is likely to mean a greater focus on management of impacts so that people can thrive in the context of flooding. Property flood resilience measures that can withstand flood water, parks and roads that can flood without causing damage, are all part of that solution.

To date the predominant emphasis in FCERM has been on assessing probability and consequences, with little effort to understand or assess resilience capacities. However

there has been some work which has focussed on community resilience or vulnerability to flooding (Twigger-Ross et al., 2015; Sayers et al., 2017). A shift towards resilience would need to include an assessment of the current resilience capacities of communities to understand how a wider range of FCERM measures might strengthen those capacities to improve resilience.

There are currently a range of measures to manage floods: flood defences, natural flood management, flood warnings, property flood resilience measures, community flood wardens etc. All these measures have a role to play, and each develops different resilience capacities.

However, while the options for measures to address flood risks generally put forward by flood risk managers or other technical staff draw on a range of flood or coastal erosion management measures, they are traditionally weighted towards engineered solutions and physical barriers. Further, flood protection is likely to be the type of measure most familiar to communities who are facing flooding and flood managers alike. This supports the desire most people feel to be free of the threat of future flooding.

If flood protection is always the first measure put forward, this will tend to create the impression that protection is the best option, and that other alternatives are less effective.

A resilience approach needs to create a different conversation with people in places facing flooding or coastal erosion impacts. These conversations will need to have three key elements:

- Understanding local flood risk, drawing on local knowledge from the experience of recent flood events and historic flood memory such as stories and place names, etc (McEwen et al., 2017; Twigger-Ross et al., 2015). A similar bottom-up approach to collecting place-based evidence is reflected in the methods used to collect data for the FRMT framework (Keating et al., 2017).

- An assessment of local capacities for managing flood and coastal erosion risks and impacts, as well as weaknesses that may need to be addressed. The value of taking a capacities approach is that it enables a greater understanding of the building blocks of local resilience. This allows for an assessment of strengths and weaknesses and ensures that resources are built on existing capacities (Twigger-Ross et al., 2017, p.27).

- Development of options for action with the active involvement of local community members to enable them to interrogate and challenge options and their implications. An evaluation of Defra's Coastal Change Pathfinders (2009-2011) found that the involvement of local residents in planning and decision-making processes led to many people overcoming their initial unwillingness to engage with the idea of coastal adaptation and to consider adaptation options (Fenn et al., 2015, p.iv, in Kelly and Kelly, 2019, p.13). Facilitated processes that bring local community knowledge together with technical expertise have resulted in the

development of novel and place-appropriate approaches based on the mobilisation of local resources, in places like Pickering and Stroud (Whatmore and Landstrom, 2011; Smith and Uttley, 2016).

This process will rely on building trust between experts and communities, whether the experts are from government organisations, like the EA or Natural Resources Wales, from local risk management authorities or private contractors. The experience of the National Flood Forum demonstrates (NFF and CEP, 2018) that this can be achieved if there is political will plus a willingness on behalf of local technical staff to create new relationships with local people which are based on mutual respect and recognition of everyone's expertise.

The ambition is that the resulting place-based assessments of community capacities and options will focus on what is desirable from the perspective of community wellbeing and ability to thrive. This will require a change in philosophy as well as in processes and procedures within risk management authorities. One issue that will need to be addressed is the availability of data on the effectiveness of non-engineered measures like flood wardens and property-level resilience.

To provide an economic assessment of the benefit of community-based resilience measures would require research to link the measures of resilience (e.g. capacities) to the reduction of damage, for example change in the depth damage curves, since that is currently the main way of calculating benefits. **Error! Reference source not found.** provides examples of approaches to calculating the benefits of community flood resilience measures:

Box 4: Examples of approaches to calculating the benefits of capacity, community-based and non-structural FCERM measures

1) Within the Multi-Coloured Manual (MCM) (Penning-Rowsell et al., 2013) the depth-damage data is available for different socio-economic categories based on occupation, with the AB socio-occupational category compared with CD reflecting higher incomes, more valuable house contents and therefore greater damage potential. It may be argued that better-off residents are more resilient than the less well-off but this is not reflected in the depth-damage data unless the better-off have been able to invest in property level resilience measures. The relationship between resilience and depth-damage data is not straightforward and this is something being looked at within the MCM update project (2019-21). This could be a way of including one aspect of inherent resilience capacity into an assessment of damages.
2) Within the Defra Flood Resilience Community Pathfinder evaluation (Twigger-Ross et al., 2015) a qualitative assessment was made linking the existence of a community group with the reduction in damages (the pathway was via provision of an earlier warning allowing people to move their furniture more quickly which reduced damages). In a similar vein there is debate around how much damage reduction could be attributed to a variety of property flood resilience measures with a view to enabling lower premiums for people at risk of flooding who put in those measures.
3) The Joint Defra / EA R&D programme carried out work to explore methods for determining the economic benefits of non-structural FCERM actions (EA, 2015). This project developed an initial version of a tool that enables calculation of economic benefits of:

- Forecasting and warning
- Emergency planning
- Working with communities
- Property level resistance and resilience

This suggests it could be possible to reflect different degrees of resilience based on occupation/income by shifting depth-damage curves upwards (or downwards) and could therefore account for inherent resilience within communities. This needs to be explored further.

If the benefits of non-structural measures could be assessed alongside traditional flood protection measures this could shift the balance from a focus on protection towards more investment in consequence reduction and in a wider concept of resilience. However, the increased likelihood of flooding due to climate change and population growth means accepting higher chances of flooding. In theory, community resilience measures could be assessed with the same risk metrics of probability x consequence.

If that were possible, measures such as property flood resilience, could be compared and combined with flood defences and other measures in a portfolio assessment[8]. In practice this type of portfolio assessment doesn't really happen. One reason is that currently there are no equivalent mature calculation methods for community resilience measures as noted above.

What this section proposes is that the concept of resilience moves us towards the idea of living well despite floods. It recognises that flood defences cannot be the only strategy given the uncertainty of climate change and that a portfolio of measures is needed. Understanding how far each of the measures in the portfolio can contribute to our overall goals of resilience is key. Having ways of valuing those benefits such that they can be evaluated against each other will be important going forward.

[8] Middlesex Flood Hazard Research Centre has provided this kind of guidance for shifting the depth-damage curves as part of the RISC-KIT EU Project (personal communication from Dr.Sally Priest).

Actions and challenges for taking forward the flood resilience approach

This section outlines the actions required and challenges to taking forward the flood resilience approach.

Actions required

1. Defining the resilience approach

This should include a clear explanation of the concept of resilience, describe the essential components that will be part of the resilience approach, establish ambitious goals and clarify how resilience will be measured.

The definition will need to describe resilience to shocks and stresses associated with both flooding and coastal erosion.

2. Establishing how the resilience approach will be operationalised

This will involve working to change internal philosophies, processes and practices in institutions and organisations involved in flood and coastal erosion risk management. Practical steps will be needed to:

- set out further detail on how resilience will be measured to enable levels to be assessed and change monitored
- establish how levels of resilience in different places will be compared
- determine how measures for improving resilience will be identified and assessed and investment decisions taken
- establish the roles of the different actors in the system
- explain how communities will be supported in improving their resilience.

One example of how this might be approached is the short case study on the role of flood defence assets in resilience (see Appendix 2). This examined the role of assets in relation to the overall flood resilience of places as well as considering the metrics that could be used to measure this contribution.

Top-down changes will involve work with practitioners to help them understand the new approach and what it means for their role. Practitioners are the key interface with communities and businesses and are often able to identify where capacities and qualities for resilience exist or are lacking. They need to be empowered to recognise the importance of these kinds of resources and develop strategies to work with communities to build them. Training courses may have a role in promoting this kind of change but the design of active learning processes that enable those involved to reflect on how change is

happening, identify obstacles and work out ways to overcome them is likely to be more supportive and effective for all involved.

The implementation of **bottom-up steps** could involve place-based data collection exercises to assess community resilience capacities and qualities. These could be led by or closely engage affected communities, through local flood groups where these exist. The process would provide a basis for determining gaps and priority needs. Some of these will require investment, others will involve capacity building.

This bottom-up approach could be tested through Pathfinder projects, involving the development of audits of community resilience (where are the sources of the community's resilience and how resilient is the community); selection /appraisal of measures to address deficits in aspects of resilience or build on strengths; implementation of measures; monitoring and learning.

Challenges

Transformative change will happen over time. Some of the major challenges to be addressed are:

- Dealing with the complexity represented by the number of agencies (from the national to the local level) that have a role in delivering flood resilience: finding a definition of resilience that works for all these stakeholders will be the first major challenge.
- Overcoming a range of obstacles to changing the way that institutions work with communities, from lack of experience and skills in working with communities, to the inbuilt biases of internal systems like performance management systems which do not recognise the value of community engagement.
- Developing data collection methods which measure resilience at the right spatial scale.

Identifying the challenges to be addressed will help to:

- Recognise the steps to be taken to produce change
- Think through the sequencing of phases
- Work with a range of actors to ensure that they play their part
- Monitor and evaluate progress towards long term goals and make changes to respond to evidence e.g. of a lack of progress or changing contextual conditions.

Recommendations for future research

Implementation of the resilience approach

Implementation of the resilience approach should be a step towards enabling communities to live well with floods which has been at the heart of flood management policy for over fifteen years. What is proposed will be different from how flooding is currently managed but builds on existing work.

In order for the approach to be used to **inform investment decisions**, gaps in evidence about the contribution of measures to increase communities' capacities to manage risk (such as property level protection, flood warning, emergency planning, awareness raising, community engagement, etc.) need to be filled, to allow these measures to be assessed alongside measures for the installation of fixed or demountable structures.

Research is currently underway to gain a better understanding of how property level protection contributes to the reduction of damage (e.g. the Environment Agency's Property Level Protection Pathfinders, 2019). However, further work needs to be done to link other measures of resilience (e.g. capacities) to the reduction of damage.

In order for the approach to **increase capacities** for delivering resilience, work needs to be done to map capacities and resources at the community level. We also need to develop a better understanding of synergies between capacities and explore where specific resources or capacities to manage flood risks are needed in addition to general resilience capacities.

To **assess the change in resilience**, relevant information needs to be collected and structured in a way that allows comparison between places in terms of a resilience profile. Work has already been done in England on developing this kind of tool (Sayers et al., 2017; Environment Agency, 2019b). This work could be built on. The method used should be transparent so that it is clear what elements contribute to the overall score, enabling a more nuanced understanding of the characteristics of resilience in different places.

Gaps to be addressed by future research

- How to value interventions to increase community resilience
    - Research is needed to understand how these interventions can be assessed
    - Research is needed to verify relationships between interventions and improvements in resilience: what impact do these interventions have? There are existing tools that can be used for this purpose (e.g. Ex-post evaluation) but these are not being used (Twigger-Ross et al., 2016)
- Factoring peoples' perceptions and feelings of coping and resilience into the assessment of outcomes: it is extremely important to understand how resilient to

flooding individuals and communities feel and how this impacts on psychological recovery. This aspect is generally not taken into account in assessing the outcomes of interventions designed to improve resilience to flooding and coastal erosion.

References

Alexander, M., Doorn, N. and Priest, S. (2018). *Bridging the legitimacy gap—translating theory into practical signposts for legitimate flood risk governance*. Journal of Regional environmental change, 18(2): 397-408.

Arcadis/United Utilities. (2017). *Measuring resilience in the water industry*. https://www.unitedutilities.com/globalassets/z_corporate-site/about-us-pdfs/looking-to-the-future/measuring-resilience-in-the-water-industry_final.pdf

Becker, D., Schneiderbauer, S., Forrester, J. and Pedoth, L. (2015). *Guidelines for development of indicators, indicator systems and provider challenges*. emBRACE Deliverable 3.5. eprints White Rose.

Bahadur, A.V., Peters, K., Wilkinson, E., Pichon, F., Gray, K. and Tanner, T. (2015). *The 3As: Tracking Resilience across BRACED*. Overseas Development Institute. Working and discussion papers.

Bennett-Lloyd, P., Brisley, R., Goddard, S. and Smith, S. (2019). *Fairbourne Coastal Risk Management Learning Project.* Cardiff: Welsh Government.

de Bruijn, K. M. (2004). *Resilience indicators for flood risk management systems of Lowland Rivers*. International Journal of River Basin Management 2(3): 199-210.

Burton, C.G. (2015). *Validation of Metrics for Community Resilience to Natural Hazards and Disasters Using the Recovery from Hurricane Katrina as a Case Study.* Annals of the Association of American Geographers.

Cabinet Office. (2011a*). Keeping the Country Running: Natural Hazards and Infrastructure.*

Cabinet Office. (2011). *Strategic National Framework on Community Resilience*.

Cabinet Office. (2017). *Public Summary of Sector Security and Resilience Plans*.

Cabinet Office. (2019). *Community Resilience Development Framework.*

Cai, H., Lam, N., Qiang, Y., Zou, L., Correll, R. and Mihunov, V. (2018). *A Synthesis of Disaster Resilience Measurement Methods and Indices.* International Journal of Disaster Risk Reduction 31.

Campbell, K.A., Laurien, F., Czajkowski, J., Keating, A., Hochrainer-Stigler, S. and Montgomery, M. (2019). *First insights from the Flood Resilience Measurement Tool: A large-scale community flood resilience analysis.* International Journal of Disaster Risk Reduction 40.

Cutter, S.L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E. and Webb, J. (2008). *A place-based model for understanding community resilience to natural disasters*. Global Environmental Change 18: 598–606.

Cutter, S.L., Burton, C.G. and Emrich, C.T. (2010). *Disaster Resilience Indicators for Benchmarking Baseline Conditions*. Journal of Homeland Security and Emergency Management, 7(1): 1-22.

Cutter, S.L., Ash, K., Emrich, C.T. (2014). *The geographies of community disaster resilience*. Global Environmental Change, 29: 65–77.

Cutter, S. 2016. *The landscape of disaster resilience indicators in the USA*. Natural hazards, 80(2): 741-758.

Davoudi, S., Shaw, K., Haider, L.J., Quinlan, A.E., Peterson, G.D., Wilkinson, C., Fünfgeld, H., McEvoy, D. and Porter, L. (2012). *Resilience: A Bridging Concept or a Dead End?* Planning Theory and Practice, 13(2).

Defra. (2004). *Making space for water. Developing a new Government strategy for flood and coastal erosion risk management in England. A consultation exercise*. London: Defra.

Defra. (2014). The National Flood Emergency Framework for England. London: Defra.

Defra. (2016). *The Property Flood Resilience Action Plan: An action plan to enable better uptake of resilience measures for properties at high flood risk.* London: Defra.

DFID. (2011). *Defining Disaster Resilience: A DFID Approach Paper*. London: Department for International Development.

Dow, K., Berkhout, F., Preston, B.L., Klein, R.J.T., Midgley, G. and Shaw, M.R. (2013). *Limits to adaptation.* Nature Climate Change 3: 305-307.

Drury, J., Carter, H., Cocking, C., Ntontis, E., Guven, S. and Amlot, R. (2019). *Facilitating collective resilience in the public in emergencies: Twelve recommendations based on the social identity approach*. Frontiers in Public Health, 7: 1–21. https://doi.org/https://doi.org/10.3389/fpubh.2019.00141

Environment Agency. (2010). *Flood resilience and resistance for critical infrastructure*. Project Summary SC080045/S1. Bristol: Environment Agency.

Environment Agency. (2014). *Calculate Grant in Aid funding for flood and coastal erosion risk management projects. Guidance for risk management authorities*. Bristol: Environment Agency.

Environment Agency. (2015). *Quantifying the benefits of flood risk management actions and advice.* Bristol: Environment Agency.

Environment Agency. (2019a). *Draft Flood and Coastal Erosion Risk Management Strategy.* Bristol: Environment Agency.

Environment Agency. (2019b). *Community Flood Resilience Project*. Internal Environment Agency Social Science Project.

Federal Emergency Management Agency (FEMA). (2017). *Federal Insurance and Mitigation Administration Community Rating System Fact Sheet*. Accessed 13 January 2020. https://www.fema.gov/media-library-data/1507029324530-082938e6607d4d9eba4004890dbad39c/NFIP_CRS_Fact_Sheet_2017_508OK.pdf

Fenn, T., Daly, E., Miller, J., Elding, C., Clarke, C., Guthrie, G., Hick, E., Frew, P., Silson, R. and Hickling, D. (2015). *Adapting to coastal erosion: evaluation of rollback and leaseback schemes in Coastal Change Pathfinder projects*. Final report for project FD2679. London: Department for Environment, Food and Rural Affairs.

Forrest, S., Trell, E-M. and Woltjer, J. (2019). *Civil society contributions to local level flood resilience: Before, during and after the 2015 Boxing Day floods in the Upper Calder Valley*. Transactions of the Institute of British Geographers. 2019, 44: 422–436.

Hegger, D.L.T., Driessen, P.P.J., Wiering, M., Van Rijswick, F.M.W., Kundzewicz, Z.W., Matczak, P., Crabbé, A., Raadgever, G.T., Bakker, M.H.N., Priest, S.J., Larrue, C. and Ek, K. (2016). *Toward more flood resilience: Is a diversification of flood risk management strategies the way forward?* Ecology and Society 21(4):52.

Intergovernmental Panel on Climate Change. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.

Keating, A., Campbell, K., Szoenyi, M., McQuistan, C., Nash, D., and Burer, M. (2017). *Development and testing of a community flood resilience measurement tool*. Natural Hazards and Earth Systems Sciences, 17: 77–101.

Kelly, R. and Kelly, U. (2019). *Community engagement on climate adaptation – an evidence review*. Environment Agency project Working together to adapt to a changing climate: flood and coast FRS17192.

Koliou, M., van de Lindt, J.W., McAllister, T.P., Ellingwood, B.R., Dillard, M. and Cutler, H. (2018). *State of the research in community resilience: progress and challenges*. Sustainable and Resilient Infrastructure. https://doi.org/10.1080/23789689.2017.1418547

Kruse, S., Abeling, T., Deeming, H., Fordham, M., Forrester, J., Jülich, S., Karanci, N., Kuhlicke, C., Pelling. M., Pedoth, L. and Schneiderbauer, S. (2017). *Conceptualizing community resilience to natural hazards – the emBRACE framework.* Natural Hazards Earth Systems Science, 17: 2321–2333.

Lamond, J., McEwen, L., Rose, C., Wragg, A., Rotimi J., Twigger-Ross, C., Papadopoulou, L., White, O., Dhonau, M. and Proverbs, D. (2017). *Supporting the uptake of low cost resilience for properties at risk of flooding: Final report* (FD2682). London: Defra.

McEwen, L., Garde-Hansen, J., Holmes, A., Jones, O. and Krause, F. (2017). *Sustainable flood memories, lay knowledges and the development of community resilience to future flood risk*. Transactions of the Institute of British Geographers, 42(1): 14-28. https://doi.org/10.1111/tran.12149

National Infrastructure Commission (NIC). (2018). *National Infrastructure Assessment: Chapter 5: Reducing the risks of drought and flooding*.

Ntontis, E., Drury, J., Amlôt, R., Rubin, G.J. and Williams, R. (2019). *Community resilience and flooding in UK guidance: A critical review of concepts, definitions, and their implications*. J Contingencies and Crisis Management 27: 2–13. https://doi.org/10.1111/1468-5973.12223

Ofwat. (2017). Resilience in the Round. Accessed 13 January 2020. https://www.ofwat.gov.uk/wp-content/uploads/2017/09/Resilience-in-the-Round-report.pdf

Palma-Oliveira, J. and Trump, B.D. (2018). *Resilience: Moving forward from a metaphor*. In Trump, B.D., Florin, M.-V. and Linkov, I. (Eds.). IRGC resource guide on resilience (vol. 2).

Parsons, M., Glavac, S., Hastings, P., Marshall, G., McGregor, J., McNeil, J., Morley, P., Reeve, I. and Staynor, R. (2016). *Top–down assessment of disaster resilience: A conceptual framework using coping and adaptive capacities*. International Journal of Disaster Risk Reduction 19: 1–11.

Parsons, M., Reeve, I., Morley, P., McGregor, J., Hastings, P., Glavac, S., Stayner, R., McNeill, J. and Marshall, G. (2017). *The Australian Natural Disaster Resilience Index: annual project report 2016-2017*. Bushfire and Natural Hazards CRC, Melbourne.

Parsons, M. (2019). *The Australian Natural Disaster Resilience Index: A profile of Australia's disaster resilience*. 12th Australasian Natural Hazards Management Conference, 2019.

Patel, S.S., Brooke Rogers, M., Amlôt, R. and Rubin, G.J. (2018). *What Do We Mean by 'Community Resilience'? A Systematic Literature Review of How It Is Defined in the Literature Version 1*. PLoS Currents Disasters. 2017, February 1.

Payo Garcia, A. (2018). *Dynamic systems: Modelling the coastal environment*. NERC Open Research Archives. Research Features 3.

Pearson, J., Punzo, G., Mayfield, M., Brighty, G., Parsons, A., Collins, P., Jeavons, S. and Tagg, A. *Flood resilience: consolidating knowledge between and within critical*

infrastructure sectors. Environ Syst Decis 38: 318. https://doi.org/10.1007/s10669-018-9709-2

Rockefeller Foundation (The) / Arup. (2015). *City Resilience Framework*. Accessed 29 May 2020. https://www.rockefellerfoundation.org/wp-content/uploads/City-Resilience-Framework-2015.pdf

Rockefeller Foundation (The) / Arup. (undated). *City Resilience Index*. Accessed 29 May 2020. https://www.arup.com/perspectives/publications/research/section/city-resilience-index

Ruszczyk, H. (2019). Ambivalence towards discourse of disaster resilience. Overseas Development Institute: Disasters. London: Overseas Development Institute.

Samuels, P. (2019) *Editorial.* Journal of Flood Risk Management 12(3):1. Chartered Institute of Water and Environmental Management.

Sayers, P., Penning-Rowsell, E. and Horritt, M. (2017). *Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK***.** Journal of Regional Environmental Change 18: 339-352.

Sayers, P.B., Horritt, M., Penning Rowsell, E. and Fieth, J. (2017). *Present and future flood vulnerability, risk and disadvantage: A UK scale assessment*. A report for the Joseph Rowntree Foundation published by Sayers and Partners LLP.

Scherzer, S., Lujalab, P. and Ketil Rød, J. (2019). *A community resilience index for Norway: An adaptation of the Baseline Resilience Indicators for Communities (BRIC).* International Journal of Disaster Risk Reduction 36.

Schipper, E.L.F. and Langston, L.A. (2015). *Comparative Overview of Resilience Measurement Frameworks: Analysing Indicators and Approaches*. Overseas Development Institute Working Paper. London: Overseas Development Institute.

Smith, B. and Uttley, C. (2016). *Case study 13*. *Stroud Rural SuDS Project: Community Engagement in Natural Flood Management.* Defra / Environment Agency project SC150005 Working with Natural Flood Management: Evidence Directory.

Surminski, S. and Tanner, T. (Eds). (2016). *Realising the 'Triple Dividend of Resilience'*. Springer International Publishing, Switzerland.

Tanner, T., Bahadur, A. and Moench, M. (2017). *Challenges for resilience policy and practice.* London: Overseas Development Institute.

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.

Twigger-Ross, C., Orr, P., Brooks, K., Sadauskis, R., Deeming, H., Fielding, J., Harries, T., Johnston, R., Kashefi, E., McCarthy, S., Rees, Y. and Tapsell, S. (2015). *Flood Resilience Community Pathfinder Evaluation. Final Evaluation Report.* London: Defra.

Whatmore, S. and Landstrom, C. (2011). *Flood apprentices: an exercise in making things public*. Economy and Society 40(4).