Environment Agency

The challenges of using social resilience indicators

From Armchair Thinking to Research and Policy

Supporting paper for project FRS20288: Measuring and monitoring resilience to flooding and coastal change

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Authors:

Bridget M Hutter, London School of Economics

Peter Bailey, Environment Agency

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Environment Agency's Project Manager:

Kate Kipling

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Foreword

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Professor Doug Wilson

Chief Scientist

Executive summary

This paper examines the challenges in implementing social resilience strategies with reference to 2 research studies in the UK, one focused on policy implementation and the second, which examined the definition and practice of resilience strategies at a local level. Both studies used disaster resilience indicators linking to geographically defined spaces to increase our understanding of the ways in which different spaces and sub-populations have various levels of vulnerability and resilience as well as diverse capacities to build resilience, to respond and to work together.

The indicators relate to 5 areas of societal resilience. These are social, economic, institutional and infrastructure and another group of indicators for community capital. The paper identifies 3 main areas of difficulty in operationalising these indicators:

- Lack of data. For example, no data for the institutional resilience and infrastructure resilience indicators are publicly available. Likewise, data are not readily available for the indicators of infrastructure resilience.

- The variability and incommensurability of the geographical boundaries used in different data sets. These difficulties arose with respect to securing data for some of the social resilience indicators. Community communication data and community capital data were available but for different levels of spatial organisation and from a variety of different sources than the base units of analysis.

- The age of the available data. The census data were 10 years old. Moreover, different data sets were collected at varying time points and intervals, therefore limiting the accuracy of these data for the present day.

As social resilience strategies become more widespread, it is essential to gain a much deeper understanding of how these strategies can be implemented. It is important that research efforts are directed at establishing what the range of social resilience indicators should be. Clearly, however, there are several issues that need to be addressed if this work is to be used more widely in the future:

- Conceptual issues: there is no agreed measure of flood resilience at a community scale in England. Research is ongoing to measure resilience, but outstanding questions remain such as is it a property of a place, people, physical infrastructure or some combination? We also need to be clear about how the term ‘resilience’ is being used: either as a capacity, an outcome or as a process.
- Improved data sources: to operationalise the social resilience indicators for flooding at a community scale, the lack of data in some of the domains (infrastructure, institutional, community capital) needs to be remedied. If the data available for considering the social aspects of resilience remain limited and partial, the heavy dominance of socio-economic data would remain and the importance of other characteristics would be neglected and unexplored.
- Access to data: this is a particular obstacle for non-governmental researchers who only have access to publicly available data. Confidentiality agreements could help to mitigate the risks here.

- Application and context: we know very little about which indicators best represent the social resilience of a neighbourhood or how these might vary in different regional, urban and rural settings. A combination of qualitative and quantitative research can contribute to both the refinement and greater theoretical understanding of resilience and its policy applications.
- At a policy level, we need to consider how this social science led work can be used in conjunction with other more natural science and engineering infrastructure led approaches to resilience both nationally and locally.

The challenges associated with using social resilience indicators should not detract from their benefits. We need to work towards improving the available data sets and help to develop a more sophisticated and inclusive resilience framework. This is especially important as it is increasingly apparent that physical resilience is not enough, particularly as we become more exposed to the effects of climate change and its resulting impact on flooding.

Introduction

There has been a growth of policy interest in social resilience over recent years. Resilience approaches have gained in popularity worldwide, partly as a response to growing uncertainties about our ability to predict and manage risks, notably in the environmental arena. There is an expanding body of resilience literature, much of it diverse and sometimes contradictory. Many armchair discussions of resilience and its benefits have added to the conceptual confusion about the meaning of 'resilience' and therefore how resilience strategies might be implemented, and their implications and effects assessed. We have a lack of empirical data upon which to base and assess policy. This paper will discuss these developments and some of the challenges we encountered in selecting and operationalising social resilience indicators for 2 different research studies, one focused on policy implementation in the UK and the second, which examined the definition and practice of resilience strategies at a local level.

Resilience

There are multiple definitions of resilience and difficulties in transferring the concept between different disciplines and domains (Adger, 2000). This has become a multi-disciplinary area with varying genealogies and meanings attaching to the concept of resilience. It has also become a fast moving and highly topical area. At the core of most definitions relating to the environment is the ability of ecosystems, societies, cities, communities, organisations and individuals to survive disturbances, shocks and surprises, to reorganise and reassemble, and to persist and maintain core systems, function and identity. Beyond this, there are various debates about the term 'resilience', for example, whether it is it an approach, a way of thinking, or a basis for action. These debates then influence more technical issues about the evaluation and measurement of resilience (Adger, 2006; Jones, 2018; Hutter, 2017).

An important shift in the literature is a move from seeking solely technical and physical protection from risks such as flooding, to giving some emphasis to the economic, political and especially social contexts within which decision-making takes place, and the needs of local people subject to risks (Tierney, 2014). This has led to a distinction between 'social resilience', which captures the social contexts and effects of risk events and physical resilience, referring to such matters as critical infrastructures, engineering defences and maintaining essential supplies and services. Physical and social resilience are connected, as demonstrated by discussions of urban resilience and the capacity of cities to recover from disasters (Vale and Campenella, 2005). In this context, social resilience focuses on the capacity of communities to stay together in the face of disaster (Kendra and Wachtendorf, 2003; Manyena, 2006). The interactions between the different facets of resilience are important, for example, understanding the interactions of social and ecological systems and how social systems may affect the resilience of the ecological systems (Janssen and Ostrom, 2006).

There is a strong aspirational aspect to many social resilience discussions with many authors regarding it positively as an approach that aims to be inclusive, open and empowering to all groups in society. But not all commentators agree with this, and caution that there may be negative articulations of resilience such as not paying enough attention to experts or shifting responsibilities from the state to individuals, therefore further disadvantaging the poorest groups (Chandler, 2014; Rogers, 2013; O'Malley, 2010). These debates are important and indicate that social resilience indicators need to consider a variety of social properties, which contribute to social resilience across a spectrum of inequality features. These may, in turn, contribute to the social resilience of a defined neighbourhood.

Social resilience discussions are most developed with reference to disaster risk reduction (Tierney, 2014) and it is this literature which has helped to lead discussions of indicators of social resilience.

Social resilience indicators

There are many different approaches to determining social resilience and each has its own epistemological approach and differing indicators of social resilience. Both of the studies discussed in this paper used the 'community resilience indicators' used by the Defra Flood Resilience Community Pathfinder Projects in 2012 (Twigger-Ross and others, 2014) and described by Forrest and others (2014). This is a version of Cutter and others' (2010) disaster resilience indicators, adapted for UK use. It sees resilience as more than physical engineering forms of resistance. Rather, it is based on the belief that resistance has a complex and crucial interrelationship with social organisations, neighbourhoods, businesses and individuals. Resilience is very much seen as a process, something that is not static and not an outcome. It involves adapting to risks and attempting to mitigate their effects, but it also implies that we are unable to manage all risks. It is accepted that 'bad things' may still happen and, when they do, the aim of resilience is that there will be an ability to 'bounce back', to keep vital systems functioning and to recover. Some of this will be the result of pre-planning, but some will take on board the need to be responsive to unknown risks. In other words, there is uncertainty, and there needs to be flexibility to cope with the unexpected. An important implication of this is that resilience is not just an inherent characteristic of an area or population. Rather, it is something that may be facilitated, nurtured, maintained, it is changing and may increase or indeed decrease (Cutter and others, 2010: 2). This is, of course, important from a policy perspective.

Discussions of social resilience have altered the ways in which vulnerability is regarded, and this is something which informed early versions of the community resilience indicators as initially conceived by Cutter and her colleagues. In their 2008 paper, they discuss the relationship between vulnerability and resilience, distinguishing 'vulnerability' as a pre-event characteristic, which indicates the potential for harm, and 'resilience' as a post-event focus on the ability to respond and recover. Analytically, this can be helpful, although there are dangers in distinguishing too much between different disaster phases. Resilience may be enhanced pre-event and vulnerabilities realised during and post event, the divisions between these phases not always being clear (Hutter and Lloyd-Bostock, 2017). A valuable aspect of the 2008 discussion is linking the indicators to geographically defined spaces, helpful in the case of flooding. It also helped increase our understanding of the ways in which different spaces and sub-populations have various levels of vulnerability and resilience as well as diverse capacities to build resilience, to respond and to work together. There is a governance and policy aspect to this, as the data can help to direct resources to where they might be most needed, to help to develop or maintain social resilience in ways that are inclusive.

The indicators relate to 5 areas of societal resilience, namely social, economic, institutional and infrastructure and another group of indicators for community capital. The schema outlines composite indicators developed to serve as proxies for each of these areas and allows comparison between different sites and time points (Cutter and others, 2010). For example, the social resilience category embraces a range of different variables such as age, special needs, language capacity, educational equity, communication capacity and transportation access. Each of these has been found to have either a positive or negative effect on resilience in the existing literature (see Table 2).

Cutter and others (2010) use these variables to generate quantitative analyses, but they can also be used in qualitative research, as in the example of case study 2 below which uses the schema heuristically to generate comparative data to help select contrasting areas of social resilience. Facilitating comparison was part of the original intention of Cutter and others' schema, so that differential social and economic capacities within and between areas could be captured (Cutter and others, 2010). Institutional resilience is more focused on the ability to mitigate, plan and decrease risk prior to a disaster, as is institutional resilience. Infrastructure resilience refers to the ability of the 'community' to respond and recover. Community capital gives us some idea of the extent to which there is a sense of 'community' and participation in the locality. Again, Cutter and others (2010) explain that this is done via proxies such as political and civic engagement.

For this approach, the indicators of resilience need to be associated with a local spatial scale. The 4 main possibilities in England are: local authorities, electoral wards, the Office for National Statistics (ONS) Lower Super Output Level (LSOA) representation of a local community, and postal codes. Each scale has its advantages and disadvantages in terms of data availability, the degree it captures the spatial variability of socio-economic indicators, and the pedigree of the data. There are many data sets available at a local authority scale, but these do not provide the spatial granularity needed for a community scale assessment of resilience, for example, flooding is a much more localised natural hazard. Electoral wards have potential, but the data sets available are limited. Post code data is widely used in commercial contexts such as marketing, but this is problematic as this data is expensive to obtain and there can be issues in identifying individual households, data protection and confidentially at such a fine spatial scale of analysis (especially for use by public agencies). Output scales have the advantage of being the standard community scale used by the ONS with official and publicly available data sets. They are designed to have similar population sizes and be as socially similar as possible, the intention being to enable indices such as Indices of Multiple Deprivation (IMD)

(MHCLG, 2019). LSOAs are the lowest geographical level at which census estimates are provided (see Table 1).

Table 1. Lower Super Output Areas (LSOAs)

Geography	Minimum population	Maximum population	Minimum number of households	Maximum number of households
LSOA	1,000	3,000	400	1,200

Source: ONS, 2011.

Table 2 outlines the variables, their expected effects on resilience and a description of the proxies for each variable in the UK context. Many of the indicators are derived from the census, with the associated data pedigree, but were collected in 2011.

Table 2. Resilience variables and data availability (Adapted from Cutter and others, 2010)

Variable and rationale	Indicators	Effect on resilience	Data availability	Unit	Data source
Social resilience					
Educational equity: Educational deprivation increases vulnerability	% of population with a Level 4 Qualification and above.	Positive	Y	Educational equity: Educational deprivation increases vulnerability	% of population with a Level 4 Qualification and above
Age: Older people may be more vulnerable.	% of population over 65	Negative	Y	LSOA and above	Census
Transportation access: No access to private transport decreases mobility	% of population without a car or van	Negative	Y	LSOA and above	Census (Nomis)
Communication capacity: Access to high speed internet	% of homes with broadband	Positive	Y	Postcode	Ofcom (2013)

Variable and rationale	Indicators	Effect on resilience	Data availability	Unit	Data source
improves access to warning system				(see below in community capital too)	
Language competency: Communities with a higher proportion of the population having English as a second language are more vulnerable	% speaking English as a first language	Positive	Y	LSOA and above	Census (Nomis)
Special need: Disability and long-term health problems increase vulnerability	% population with long-term health problem or disability	Negative	Y	LSOA and above	Census (Nomis)
Economic resilience					
Housing capital: Home owners are more likely to be able to access economic resources	% home ownership	Positive	Y	LSOA and above	Census (Nomis)
Employment: employment is usually associated with higher economic resources	% economic active % employed	Positive	Y	LSOA and above	Census (Nomis)
Income and equality: Income deprivation is equivalent to low	Indices of deprivation: % in	Negative	Y	LSOA and above	Census (Nomis)

Variable and rationale	Indicators	Effect on resilience	Data availability	Unit	Data source
economic resources	the top 10% of income deprivation				
Single sector employment dependence: Reliance for employment on sectors that are at risk of damage or disruption from flooding (for example, farming, fishing, forestry) increases likelihood of disruption from flooding	% employment in fishing, farming, forestry or extractive industries	Negative	Y	Ward and above	Census (Nomis)
Institutional resilience					
Flood coverage: Flood insurance reduces financial consequences of flooding	% of houses covered by insurance for flooding	Positive	N		
Municipal services: Emergency service provision reduces vulnerability	% Local Lead Flood Authority expenditure for emergency services	Positive	N		
Mitigation (1): Flood preparedness (awareness) reduces vulnerability	% population signed up for flood alerts	Positive	Y	Flood warning zones converted into LSOA data	Environment Agency (internal data set)

Variable and rationale	Indicators	Effect on resilience	Data availability	Unit	Data source
Mitigation (2): Flood preparedness **(existence of flood wardens) increases capacity to respond**	Number of flood wardens in area of influence	Positive	N	Incomplete, inconsistent local data	Environment Agency
Previous disaster experience: Previous flood experience increases resilience (preparedness) but is affected by the amount of flood damage	Number of previous floods in x years affecting over 100 properties Flood damage per flood	Positive	N	Locally collected data. No national data set	Environment Agency
Infrastructure resilience					
Housing style: Temporary and mobile homes are less resilient	% housing units that are not bungalows or mobile homes	Positive	N		
Shelter capacity: The availability of temporary accommodation makes it easier to rehouse flooded people	Units of accommodation available for homeless people	Positive	N		
Recovery: Evacuation centres provide a safe place for people to go	Number of designated evacuation centres	Positive	N		

Variable and rationale	Indicators	Effect on resilience	Data availability	Unit	Data source
Community capital					
Place attachment: Migration over short term is associated with reduced sense of belonging	Net migration to area of influence over past 5 years	Negative	Y	Local authority level	ONS
Political engagement: Political engagement increases community's ability to influence decisions and access resources	% voter participation in elections	Positive	Y	Constituency level (Ward level turnouts will also be available for local elections)	Electoral Commission
Social capital – civic involvement: Organisations increase the networks of relationships and support	Number of community /voluntary / religious organisations in area of influence	Positive	N		
Broadband coverage: Broadband coverage increases community's ability to access information and local online groups	Percentage of households where super and ultra-fast fixed broadband is available. Ofcom Connected Nations 2018 report	Positive	Y	Available at output area, postcode and local authority level	Ofcom

Variable and rationale	Indicators	Effect on resilience	Data availability	Unit	Data source
Mitigation and social connectivity: **Community engagement in flood action groups increases ability to respond to flooding**	Number of flood action groups or community resilience groups in area of influence	Positive	N		

This approach informed 2 independent but complementary research studies. The first was to establish workable indicators for social resilience to incorporate into flood planning. The second required a simplified version of social resilience indicators to help select neighbourhoods which are at medium to high risk of flooding and with contrasting profiles of social resilience. Both case studies converged on similar data sets for the reasons above. The rest of this paper will discuss how each study used the indicators. We will then reflect on the difficulties of operationalising them as well as the potential benefits.

Case studies

Case study 1: Mapping community resilience to flooding in England

The Environment Agency has increasingly adopted the term ‘resilience’ within its work on flood risk management. The purpose of the research by the Environment Agency’s social science team was to develop and test a method for mapping community resilience to flooding at a local scale that could be applied across England. The work aimed to trial and test the concept, as the team knew that there would be a range of potential applications. Specifically, an objective of the project was to provide a ‘proof of concept’ – to demonstrate that a quantitative model and associated map of England could be produced.

Over the past two decades, the Environment Agency has used 2 methods for characterising the socio-economic characteristics of places in England in its flood management practices and procedures. First, there was the social flood vulnerability index (SFVI) developed about 20 years ago (Tapsell and others, 2002) by Middlesex University. The Environment Agency applied this in prioritising flood defence schemes until replacing it with a second method focused on deprivation. One of the main reasons for the change was the availability of an authoritative, cross-government and widely used measure of deprivation, the Index of Multiple Deprivation (IMD). The IMD was incorporated first into the Environment Agency’s flood scheme delivery targets set by Defra and the Coalition

Government in 2010 (Environment Agency, 2015). The policy framework evolved in 2012 with the introduction of the Partnership Funding policy (Defra, 2013). This gave higher government funding for schemes in deprived areas, defined as the 20% most deprived areas as measured by the IMD. This method continues to be used. In practice, both the vulnerability and the deprivation indices rely on many of the same underlying indicator sets, an issue for resilience metrics too. The use of these indices has fitted comfortably with Environment Agency flood risk management practices and procedures as they can be used to represent differential flood risks and impacts resulting from socio-economic characteristics. However, as flood resilience has emerged in academic and policy discussions, it was decided to explore whether a new socio-economic metric was feasible and potentially useful. Potentially, a resilience metric could capture communities' abilities to prepare, respond and recover from flooding. This reflects, in part, flood policy framings of individuals and communities as having capacities and responsibilities to prepare and respond to flooding. A community resilience metric would therefore offer one way of bringing these considerations into flood management policy and administrative practices.

This case study followed an evaluation of 20 Defra funded projects between 2013 and 2015, which aimed to 'improve the community's overall resilience to flooding' in a Flood Resilience Community Pathfinder scheme (Defra 2012). The evaluation (Twigger-Ross and others, 2015) was informed by the work of Susan Cutter (reviewed above) and applied 5 categories to analyse the performance of these projects. These were social resilience, infrastructure resilience, economic resilience, community capital, and institutional resilience. The next stage of the work (case study 1) centred on exploring what quantitative indicators were available, and at what spatial scales, for each of these domains. As the Environment Agency's remit covers all of England, our preference was for national data sets that represented social characteristics consistently at a community scale. As discussed above, we decided to use the ONS LSOA representation of a local community (see Table 1). This provides access to many nationally consistent data sets. It is a spatial unit that is similar in scale to many of the physical characteristics of flooding as set out in the Environment Agency's flood risk management practices. We explored what data sets were available and went through several iterations of the model. Two Environment Agency flood risk management databases also provided indicators:

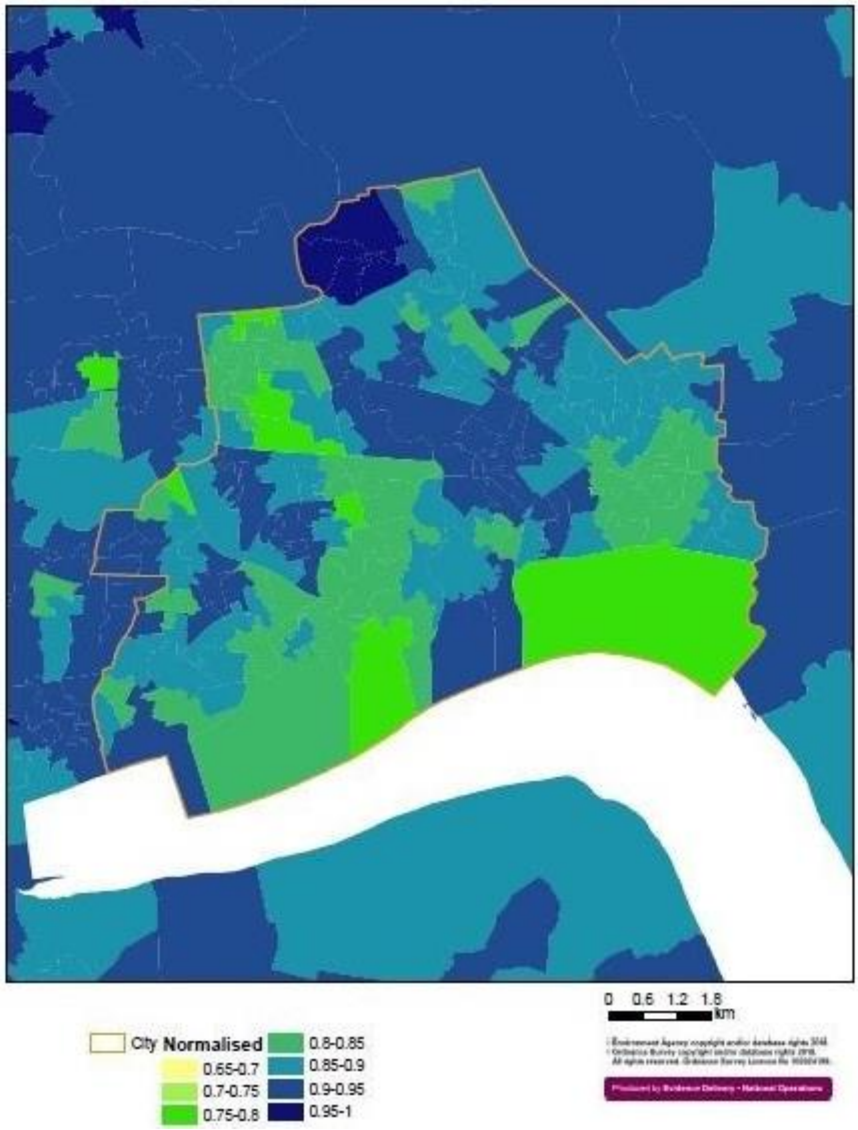
- Properties at risk and Community establishments indicators: the Environment Agency's properties at risk of flooding database (Environment Agency, 2020a) was used to identify properties in areas at risk. The database also was used to identify the location of critical community services, including hospitals, GP surgeries and schools.
- Flood warning sign up indicators: these indicators differentiate between people who are actively and automatically added to the flood warning service from the Environment Agency's flood warnings database. This is an internal Environment Agency database used within the flood warning service and not available as open data.

The version of the model presented in this case study had 6 indicators for the social resilience domain, 2 for the infrastructure resilience domain, 5 for the economic resilience domain, 2 for the community capital domain and 2 for the institutional resilience domain. After agreeing on the composition of the indicators for each of the domains, we proceeded to operationalising these indicators. This stage involved choosing a set of proxy variables that would appropriately measure each of the indicators, allowing us to compare different indicators and develop a composite community resilience score.

Although it was not difficult to select indicators for each of domains, which in theory meant we could have an equal number of indicators for each domain, the 2 main issues were data availability and consistent spatial scales. For example, for community capital, we had explored using voter turnout at local and constituency level elections. However, it was not possible to convert this data to the spatial scale used in the model, that is, the LSOA level. Cutter (2014) had cited 7 indicators for community capital, but the data for this domain is not readily available. For example, volunteering data does exist, but it is not collected uniformly and at a LSOA level across the whole of England. The data sets were being sourced from the 2011 census data produced by the ONS, which made the data quite old. However, using census data gives us the advantage of being able to regularly update the index, which was a piece of feedback we received from the senior management of the Environment Agency.

The resilience model was constructed in a Microsoft Excel spreadsheet and the data were then displayed in a geographical information system (GIS). A value for each indicator at LSOA geographical scale was obtained. We then used a standard statistical technique – the Z score. This enabled the indicators to be normalised in the model. An aggregated score for each domain was then calculated. These were combined to provide the composite community resilience score. At all stages, the Z score approach was used to provide normalised scores using a minimum to maximum rescaling scheme between 0 and 1. Therefore, the final community flood resilience score ranges from 0 to 1, with the more resilient communities having the higher scores. Further details of the quantitative analysis are recorded in the Environment Agency project documentation (Environment Agency, 2019). Figure 1 provides an example of the GIS mapping output for Kingston upon Hull. The higher the score, the more resilient a community, according to the model estimate. The map shows that resilience, as estimated by the model, varies across the city, with a number of communities (as represented by LSOA) next to the estuary (shown in white on the map) having a lower resilience score (in green). Some communities in the city, shown in blue on the map, have higher levels of resilience and these can neighbour areas of much lower resilience. This demonstrates how community resilience can change significantly between adjoining communities.

Figure 1. Example map of community resilience to flooding for Kingston upon Hull



The Environment Agency employs Flood Resilience Engagement Advisors (FREAs) in its Area Operational teams. These staff members have on-the-ground practitioner experience of working with flood affected communities. The next stage of the project was to discuss and benchmark the community resilience model outputs with FREAs' professional and local knowledge of the places and communities they work with. This was done in 5 urban areas. It is not possible for FREAs to work in all communities at risk at the LSOA local level, which meant that Environment Agency staff were familiar with some but not all the places in the maps provided. In addition, flood officers do not examine communities at this spatial scale, and for all the flood officers this was the first time they had considered resilience from this point of view. Communities do not naturally fall into the boundaries of 'super output areas' and therefore, this presented a challenge when viewing the maps. When the advisors were familiar with a locality, the resilience map did tend to agree with their knowledge and experience. As well as the physical characteristics of flooding, the socio-economic characteristics of a community are important for FREAs' work in a place. FREAs are generally aware of the makeup of a community, in terms of household composition, age structures, levels of employment and income and educational attainment; all indicators in the social and economic resilience domains. These community characteristics play an important role in the way that engagement takes place, as they offer clues into some of the challenges that households face in becoming resilient to flooding. However, we cannot expect FREAs to know the general features of every community. This is where the model can help in highlighting important LSOAs that may need further investigation when the scores for community resilience are low. The model also helps because it is evidence-based, rather than just based on observations made on the ground, which might be subjective. Conversely, we also found that FREAs were interested to learn where resilience scores where high and what attributes led to these high estimated levels of resilience.

These socio-economic characteristics are a major part of the community resilience model and it is these dimensions that the FREAs recognised. However, local Environment Agency flood officers' work is practice-based such as helping communities to develop flood plans or working with flood wardens. They did not disagree with the resilience maps but had to work to see how the maps related to their current working practices. The maps did conform to FREAs' assumptions about levels of resilience within different communities on the whole. There were a couple of instances when the resilience scores were much lower than they expected. This was because regeneration of an area had taken place over the past decade but some of the data sets were 10 years old. In another instance, the demographic makeup of an area had changed markedly as there had been an influx of people into an area from European countries which wasn't reflected in the census data. Overall, the consensus was that the maps provided a good way of checking the levels of community resilience, where they could highlight important hot spots, in terms of high and low levels of resilience. This, in turn, could inform where and how much engagement might be needed within a particular location.

Overall, the project team considered that the community resilience model and associated maps met the objective to provide a 'proof of concept'. In principle, the work has many applications in the Environment Agency. This ranges from strategic national work such as prioritising resources to communities and places with lower resilience to local uses such as identifying local communities that may have low resilience and are not receiving bespoke support at present. However, the approach, so far, has several limitations, and improvements would have to be made for the approach to be used in practice. These considerations are examined in the discussion below.

Case study 2: Risk regulation and resilience flooding strategies and inequality in the UK

The purpose of this university-based research was to examine the definition and practice of UK resilience strategies, particularly in local governance structures and within the local population. An important consideration was the extent to which the policies and practice of resilience strategies are intended to be participative and, if so, who participates or would be willing to participate.

This paper is concerned with the selection of 2 research areas for the empirical study. This was a qualitative study, based on researching the experiences, understandings and views of those living in areas at risk of flooding. The emphasis was on resilience as a social concept where the focus is on ‘community’, ‘neighbourhood’, people and organisations rather than physical infrastructures, although views about the physical resilience are, of course, important. The importance of these types of qualitative data is that they help us to understand much more clearly how resilience strategies might be implemented in ways that are more likely to increase their uptake. They help us to understand the limits of resilience and the conditions under which these strategies can gain support, and when risk strategies might be more opportune. They also help us to understand perceptions and concerns about the risks and uncertainties posed by flooding, along with issues that influence the willingness and ability of people to participate in decision-making about the governance of flooding. The social resilience literature suggests that some groups will be more receptive than others, and that there may be inequalities attaching to the constitution, practice and outcomes of different strategies. The aim was therefore to include areas with contrasting social resilience profiles.

The process and mechanics of sample selection

The first task was to identify geographical areas at risk of flooding and then to focus in on 4 areas to include in the research. We started by looking at one region of the UK which has a history of flooding and consulted Environment Agency flood maps to determine which local authority areas within that region were at risk of flooding. Local authorities are administrative areas with local government responsibilities, such as providing local services and some flood management responsibilities. The research focused on two-tier authorities where the county council is the Lead Local Flood Authority. Under the legislation, lead authorities are responsible for co-ordinating flood risk management in their own area. Within each county council, there are second tier district councils that are responsible, together with the Lead Local Authority, for the risk management of minor watercourses . In coastal areas, district councils also act as the coastal risk management authority. District councils are often the local planning authority and, as such, they are responsible for Local Development Plans and Planning Committees which decide on planning applications. There is a direct connection here with the local population who can comment on Neighbourhood Plans, often through town or parish councils, which constitute the third tier of local government, and are intended to provide a democratic voice for local populations.

We used Environment Agency flood maps intended to help with planning (‘Flood Map for Planning’), to select first a county council and then 2 district council areas within that county in which to conduct the empirical research. The Environment Agency maps delineate flood zones, indicating the likelihood of flooding across a region (Environment Agency, 2021a). We selected local authority areas with properties in Flood Zone 3, which comprises the areas most at risk, with land having a 1 in 100 or greater annual probability of river flooding; or a 1 in 200 or greater annual probability of sea flooding. The flood maps show which flood zone a property is located within, the location of flood defences and details of the areas benefitting from flood defences. They do not take the presence of the defences into account when calculating the probability of flooding, nor do they take other sources of flooding, such as surface water flooding, into account. The term ‘residual risk’ is used to denote the risk that remains should, for example, flood defences fail perhaps because of poor maintenance or weather conditions which exceed the design standards used in the defences.

Once we had examined the data at county and district council levels, we focused in on smaller geographical areas and considered the flood risk in different electoral wards, which are the spatial units used to elect councillors. We looked at the flood risk figures at ward level using National Flood Risk Assessment (NaFRA) flood maps ‘Risk of flooding from rivers and sea’ (Environment Agency, 2021b). This is a national assessment of flood risk managed by the Environment Agency which shows the risk of flooding from rivers and the sea in spatial units of 50 square metres. Surface water flooding maps ‘Risk of flooding from surface water’ (Environment Agency, 2013) use the same risk bands, but the Environment Agency cautions that these are especially difficult to predict. NaFRA data give a general indication of flood risk in an area, moreover they include the risk reduction provided by flood defences, but they do not provide information about the flood risk of individual properties. It is a data set that can help to raise public awareness of flood risks and provide some general guidance for local authorities. Given limited resources, we considered the flood risk for residential premises (not business premises) and the risk bandings high, medium and low. The properties at risk were estimated by counting the number of National Receptor Dataset (NRD) points which lie within each specific banding. These are the number of property points on a national data set for Environment Agency use, with information about their risk of flooding. These ward level data were used in the research to select a variety of possible research sites located in Flood Zone 3 and which included properties at high risk of flooding.

In District Council A, we considered 5 areas at risk of flooding according to ward level data and then analysed NaFRA maps ‘Risk of flooding from rivers and sea’ for these areas to find the LSOAs most at risk. In District Council Area B, we considered 4 areas following the same process. We simultaneously examined the social resilience indicators for each LSOA. We selected 2 LSOAs in each district. This case study also considered governance structures to gain some sense of whether these made any difference to participation. The governance in place for Districts A and B are slightly different. Both sites in District A fall under the same second tier of government, a city council, and there is no third tier of government in this area. This contrasts with District B, where District Council B is the second tier of local government with some flooding responsibilities, but there are also third tiers of local government for sites 3 and 4. These also have town councils, they do not have any flooding responsibilities, but they do represent a layer of government which is, theoretically at least, closer to the local population.

A major decision we had to take was whether to focus on areas that had recently experienced flooding or those deemed to be at high risk but which had not recently experienced any major flooding. After much consideration, including discussions with the regional Environment Agency officers, we decided to opt for the second, more difficult option. There were 2 main reasons for this. Firstly, these areas posed more of a challenge when considering the feasibility of introducing social resilience strategies proactively rather than after a major flooding event. Would local councillors and the local population be aware of the risks and, if so, would they be willing to participate in efforts to improve resilience? In District A, additional challenges were potentially present in the form of a transitory student population. Making this decision distinguished the research from much other social science research on flooding and social resilience which has tended to occur post flooding. The second reason for this choice was that it potentially offered the opportunity in District B to consider a situation where there had been no recent sustained Environment Agency activity to raise flooding awareness, and where there were plans for this to happen going forward. So, it offered the chance to establish a baseline of interest, with the possibility of returning later to see if interest had increased as the risk and plans were being more publicly discussed. Moreover, the research could be helpful in this case in terms of gathering data about the extent to which the local population understand the flooding risks to which they are exposed, and how much importance they attribute to improving flood defences and resilience.

Difficulties in using the available data and operationalising social resilience indicators for policy and research purposes

The resilience framework used in these case studies required data for each of the indicators in the different categories of resilience (see Table 2). Securing the requisite data involved practical difficulties, some of which have implications for the robustness of the findings.

A major obstacle to substantiating some of the resilience indicators was the unavailability of data. This is an issue encountered by numerous other projects attempting to use social resilience indicators (for example, UK Pathfinder Projects - see Forrest and others, 2014). It is telling, which data are available, and which are not. No data for the institutional resilience and infrastructure resilience indicators are publicly available. Insurance data are regarded as proprietorial and are not even shared with governance agencies. Mitigation data such as the proportion of the population signed up for flood alerts, the number of flood wardens and previous disaster experience (number of previous floods) are all data one might expect to be readily at hand. The fact that they are not publicly available nor apparently easily secured by request is a limitation for researchers and the data officials have available. Likewise, it is surprising that data are not readily available for the indicators of infrastructure resilience (housing style, shelter capacity, and recovery evacuation centres). The Environment Agency research team was able to access internal Environment Agency data sets that could be adapted to provide a small number of indicators for infrastructure and institutional resilience. Nevertheless, some domains of community flood resilience are weakly represented in the case study 1 model because of the availability of appropriate data sets. Likewise, this affected the accuracy of the data used to select a sample in case study 2.

A second issue both studies encountered was the variability and incommensurability of the geographical boundaries used in different data sets. These difficulties arose with respect to securing some data for the social resilience indicators. Generally, LSOA data were available for most of the social resilience and economic resilience indicators (see Table 2). This is not surprising as these are the data collected for census purposes. The exceptions in these categories were ‘communication capacity’ indicators which are available at postcode level from Ofcom and single sector employment dependence data which are collected by the census but only at ward level. Community capital data were available but for different levels of spatial organisation and from a variety of different sources. ONS data for place attachment (net migration to areas over the past 5 years) were available at local authority levels. Political engagement (percentage of voter participation) is available from the Electoral Commission at constituency level and at ward level for local elections.

Where different data sets were used, there were difficulties in mapping the boundaries they used against LSOA boundaries. The Environment Agency research team had access to internal GIS (Geographical Information Systems) and GIS technicians, therefore was able to convert data sets between different geographies. For example, both the NaFRA/properties at risk and the flood warning data sets were mapped onto the LSOA geography required for the model and mapping approach in case study 1. GIS was not available to university-based researchers in case study 2, and they encountered time-consuming difficulties mapping LSOA boundaries onto flood maps. It must be remembered that the policy purposes for which these data sets were compiled did not include mapping flooding areas with areas of small-scale census data (see above). Environment Agency flood maps are for generic planning purposes. The NaFRA mapping is the result of general country-wide modelling. These publicly available flood zone maps were very useful in giving a general indication of which county and district councils would be worth considering for case study 2 and which electoral wards are at a risk of flooding. More specific neighbourhood data were more difficult to secure, especially the level of data required to assess which LSOAs are at risk of flooding. This involved matching up the NaFRA mapping with LSOA boundaries and identifying the properties at risk. These were identified on the maps as coloured dots. To ascertain the number of properties at risk, the dots had to be counted within the LSOA boundaries. However, it became clear that the dots are very indistinct regarding location. In some respects, this is intentional in the hope that confidentiality might encourage greater flood reporting, but it caused delays in the research. Quite late into the first year of research we were able to secure some more nuanced data about which roads (but not which properties) in the LSOAs being considered were affected by flooding. In District B, it became clear that the data the researchers collated using publicly available data was far removed from the more nuanced data. This caused us to change one of our selected LSOAs because Environment Agency flooding figures revealed that our first choice had relatively few properties at risk of flooding. We therefore selected another LSOA which had a greater number of properties at risk of flooding, but which did not offer as great a contrast with respect to social resilience.

Table 2 identifies the availability of the data for each indicator, the unit level of data available and the data source. Where we could not secure precise LSOA level data for an indicator, we took the next level of available data as a proxy. Inevitably, this leads to some potential inaccuracies in the data we used. A third and related concern is the age of the data we have available. The census data were collected in the last UK census in March 2011, the Ofcom broadband postcode level data are from 2013, and the Electoral

Commission voter turnout figures are for 2017. One issue arising from this is the accuracy of these data for the present day. We had to be aware of this limitation throughout the projects.

The practical difficulties we encountered with the data needed to operationalise the resilience indicators at a neighbourhood level necessarily constrained the robustness of the emerging model in case study 1 and the sampling data for case study 2. In addition, as with any data set, it should be remembered that each set of data has its own limitations. We need to remain sensitive to these limitations and to the heuristic nature of the proxies we have for the resilience variables. We also need to turn our attention to how to develop, refine and improve our understanding of the social aspects of resilience, particularly at a neighbourhood level.

Discussion

As social resilience strategies become more widespread, it is essential to gain a much deeper understanding of how these strategies can be implemented. It is important that research efforts are directed at establishing what the range of social resilience indicators should be. The Pathfinders Project made important initial steps in starting to adapt an important tried and tested US-based scheme of assessing social resilience for UK purposes, but this needs further development and refinement. In this paper, we have discussed some of the challenges we encountered in selecting and putting these resilience indicators into practice for 2 different research studies; one focused on policy implementation in the UK and the second, which examined the definition and practice of resilience strategies at a local level. In many respects, these 2 studies are complementary.

The Environment Agency's flood and coastal erosion risk management strategy for England (Environment Agency 2020 (Environment Agency, 2020b) sets a long-term vision for flood and coastal erosion risk management, with an increasing emphasis on resilience approaches. The Environment Agency is working with others on how to implement the strategy. This includes how to incorporate social dimensions of resilience into a wider definition of 'place-based resilience'. The Environment Agency's strategy definition of flood and coastal resilience focuses on the interventions (flood resilience actions) that can be applied or developed in a place to reduce the likelihood and impacts of flooding and coastal change over time. Quantitative modelling of social resilience and flooding are needed for policy purposes (Demortain, 2019; Espeland and Stevens, 2008; Porter, 1995). Case study 1 was designed to demonstrate the usefulness of social data, analysis and quantitative modelling to improve understanding, and the implementation of flood resilience approaches. But, we also need to know how well the indicators in these models reflect what is actually going on in neighbourhoods through the country. It is here that qualitative research such as case study 2 can help to refute or verify some of the assumptions in the modelling. For example, we still know very little about which indicators best represent the social resilience of a neighbourhood or how these might vary between nations and within nations. A combination of qualitative and quantitative research can help us strengthen our understanding and refine our concepts here. Clearly, however, there are several issues that need to be addressed if this work is to be used more widely in the future.

First, there are conceptual issues. A review of evidence published by Defra in 2020 (Twigger-Ross and others, 2020) explored the concept of resilience in the flooding policy context. The review, like many before it, found varied definitions and applications of resilience, with differing emphasis on physical and social characteristics. There is no agreed measure of flood resilience at a community scale in England. Flood resilience is described in qualitative terms and in terms of flood management actions that increase resilience. For example, Defra’s 2020 Policy Statement (Defra, 2020) does not define resilience, and emphasises the management actions that are being taken in the short and medium term to reduce flood risk and/or increase various forms of resilience (infrastructure, property, business and community). Similarly, the Environment Agency’s 2020 strategy (Environment Agency, 2020b) emphasises the range of resilience actions that can be taken, although it does start to expand on the concept of resilience: “We frame resilience in terms of the capacity of people and places to plan for, better protect, respond to, and recover from flooding and coastal change. This includes making the best land use and development choices, protecting people and places, responding to and recovering from flooding and coastal change, while all the time adapting to climate change” (Environment Agency, 2020b). Research is ongoing to measure resilience, but outstanding questions remain such as is it a property of a place, people, physical infrastructure or some combination? We also need to be clear about how the term ‘resilience’ is being used: either as a capacity, an outcome or as a process. The community flood resilience modelling and mapping approach in case study 1 would have to fit with how these questions are answered both in scientific and research terms. It is for this reason that government departments and agencies have evidence specialists that have an eye on both the policy context and the emergent academic research findings. Flood resilience as a concept and a practice are perhaps best described as work-in-progress in both policy and scientific terms.

A second issue that needs addressing is that we need to improve our data sources. To put the social resilience indicators into practice for flooding at a community scale, the lack of data in some of the domains (infrastructure, institutional, community capital) would have to be remedied. We encountered difficulties in using existing data sets compiled for very different purposes than we were using them for. If the data available for considering the social aspects of resilience remain limited and partial, the heavy dominance of socio-economic data would remain. Therefore, while it might be possible capture social and economic resilience characteristics, what would be neglected would be the importance of institutional and infrastructure resilience characteristics and indicators of community capital. It is not clear that such an approach, with limited infrastructure, institutional and community indicators, provides significant advantages over existing community scale indices such as the Index of Multiple Deprivation (IMD). Can existing data sets, such as the census materials, be reliably used or do we need to collect bespoke data, particularly for some of the gaps in the existing data available to policymakers and researchers? For example, if we frame flooding as a social-economic impacts issue, it might make sense to include it in the basket of socio-economic policy challenges that the IMD seeks to capture.

Alternatively, we might consider something bespoke as flooding is different, for example, because of the physical geography characteristics of flooding and the importance of historic decisions on infrastructure. Therefore, do flood resilience indicators need to be tailor made to be useful for policy and delivery purposes?

Access to data can also be a research obstacle. Case study 2 researchers encountered time-consuming difficulties reconciling the different geographies used in publicly available data when internal government data sets had already reconciled these issues. If it were possible for university researchers to have access to some of the internal data sets used by official agencies such as the Environment Agency, this would be very helpful. Likewise, it is not possible for researchers to access data on insurance cover, for example from Flood Re. Obviously, there are issues of confidentiality involved but confidentiality agreements could help to mitigate the risks here. One positive step in the right direction is that NaFRA data are currently being improved. NaFRA 2 is being implemented at the moment and some of the data problems attending NaFRA 1 are in the process of being fixed. For example, NaFRA 2 will have improved modelling, including incorporating more detailed and accurate local models, and more robust and consistent management of data.

Once we have a clearer idea of which social resilience indicators we can secure usable data for and how they might be measured or which proxies can be sensibly used instead, we can focus on how to weight different indicators. At the moment, we do not know which variables are most important in promoting and measuring social resilience. The existing data are skewed to consider the importance of inequalities through the availability of IMD data. This is, of course, an important topic, but we also need to know the status of other variables in promoting resilience, notably institutional resilience, infrastructure resilience and community capital variables. Moreover, these data could be used to take a broader view of all aspects of neighbourhood resilience, so that the data, measures and modelling can be used not just for flooding, but for all civil contingency issues – pandemics being the obvious one at the moment.

The third set of issues which demand attention relate to application and context. These issues are important as they contribute to both the refinement and greater theoretical understanding of resilience and its policy applications. The effects of different indicators are still unclear. For example, the existing literature has contradictory findings on the effects of previous disaster experience. The conventional belief is that previous experience increases social resilience. However, there is some evidence that this is not invariably the case and it may well be influenced by the amount of flood damage experienced (Wachinger and others, 2013). We need to have a better understanding of how these issues might vary in different social contexts, for example, different national and cultural contexts and varying regional, urban and rural settings. Case study 2 also considered different governance levels and their possible effects on neighbourhood participation levels contributing to neighbourhood resilience.

At a policy level, we need to consider how this social science led work can be used in conjunction with other more natural science and engineering infrastructure led approaches both nationally and locally. For example, case study 1 was led by the Environment Agency's social science team. For the work to be of wider use in the Environment Agency, it is likely that it will need to be co-developed and co-produced with the teams who would use it, such as national strategy teams and local operational teams. This is for 2 main reasons. Firstly, to understand more fully the context in which the approach would be usefully applied and, secondly, to provide it in a form that these teams can practically use.

While this paper has focused on the challenges associated with using social resilience indicators, this should not detract from their benefits. The resilience framework used in these and many other resilience studies should not be thrown out because of deficiencies in the data that are currently available. Rather, we are arguing that we need to work towards improving the available data sets and help to develop the full resilience framework. We can use the available data in the UK to work on the social and economic resilience parts of the framework using census and IMD data. We certainly need a much more deeper understanding of the impact of the various dimensions of these variables in contributing to flood risk resilience. But we also need to broaden our understanding of the other variables and their interrelationships with each other and in varying social and geographical settings. This is especially important as it is increasingly apparent that physical resilience is not enough, particularly as we become more exposed to the effects of climate change and its impact on flooding. We currently have a lack of empirical data upon which to base and assess policy, particularly at a local level. More work is needed to strengthen our evidence-based data. The 2 cases we refer to in this paper have made a start at putting into practice what has previously been a research discussion. What we have can probably be used for some, although not all, flood management purposes. It can usefully complement the existing range of natural science and engineering dominated management tools and practices and serve as a basis for developing something more sophisticated and inclusive for the growing demands of the 21st century.

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