Does the concept of “resilience” offer new insights for effective policy-making?

An analysis of its feasibility and practicability for flood risk management in the UK

Shen Gao

Department of Land Economy
University of Cambridge

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Declaration

This thesis is submitted according to the requirements of the Degree Committee of Land Economy. It does not exceed the regulation length of 80,000 words including footnotes, references and appendices. It is the result of my own work and includes nothing which is the outcome of work done in collaboration with others, except where specifically indicated in the text and Acknowledgements

Shen Gao
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Abstract

The concept of resilience is increasingly applied to policy-making. However, despite its widespread use, resilience remains poorly defined, open to multiple interpretations, and challenging to translate into practical policy instruments. Three particularly problematic aspects of resilience concern its rigid conceptualisation of adaptation and learning, its de-politicised interpretation of participatory decision-making, and the ill-defined role and relevance of social vulnerability indicators. My research analyses these three aspects within the context of flood risk management in the UK, which is uniquely suited to studying the practicability of a cross-disciplinary concept like resilience, because it connects issues of natural resource management, social planning, and disaster management. First, I analyse two case studies of experimental pilot projects in natural flood management. Through studying project reports, and interviewing stakeholders involved in project implementation, I determine whether the theorised learning-by-doing method in resilience is reflected in experiences from real experimental projects. Secondly, I use one of these case studies to map out the political structure of local participatory bodies in flood management, and also conduct a small survey of local community groups. The purpose of this second study is to determine if collaborative methods can indeed lead to a knowledge-driven policy process as envisioned in resilience literature. Lastly, I use statistical analysis to compare a traditional flood management model and a socio-economic model. The aim of the statistical modelling is to determine whether socio-economic factors are indeed useful for informing flooding policy, and whether they offer new insights not already being used in modern flood management. I find that resilience gives insufficient consideration to the importance of political constraints and economic trade-offs in policy-making, and that evidence for the usefulness of socio-economic factors is inconclusive. Future work could focus on further refining the statistical modelling to pinpoint empirically verifiable indicators of resilience.

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Chapter 1

Introduction

In recent decades, there have been notable changes to the regularity and pattern of extreme weather and climate events across the globe, and some of this observed climate change is attributable to human influences. Climate change is expected to continue for the foreseeable future, will amplify and create new risks for natural and human systems, and increase the likelihood of severe and pervasive impacts on societies (IPCC, 2014). It is generally agreed that the most appropriate response to climate change is to attempt to limit global warming to no more than 2ºC by reducing the world's greenhouse gas (GHG) emissions (IPCC, 2014). However, regardless of the success of the efforts to reduce GHG emissions, it is assumed that some changes in the climate are inevitable, due to the considerable uncertainty surrounding estimates of the magnitude of future warming and its impacts (CCC, 2015). Therefore, in addition to preventive measures aimed at the root causes of climate change, there is also strong agreement that initiatives intended to prepare and adapt societies to the consequenes of climate change - most notably increasing frequency and magnitude of natural hazards such as droughts,floods, and storms - are also needed (Bulkeley and Broto, 2013; HMG, 2012). One concept that is arguably suited for dealing with the possibilities and uncertainties resulting from climatic change, is *resilience*, which is increasingly used by those in the disaster risk reduction (DRR) field to study how the harmful impact of greater and more frequent natural hazards can be reduced (Carpenter et al., 2012; Fekete et al., 2014). The concept has grown in influence over the past decade, and now rivals sustainability as an omnipresent catchphrase in climate change adaptation literature, with numerous government bodies producing reports intended to develop resilience-building toolkits for practitioners (Jha et al., 2013; UNISDR, 2012; WB, 2008). The increasing usage of *resilience* to guide policy decisions is somewhat precipitant however, since it is currently vaguely conceptualised, which can limit its value for informing practical policy-making.

Proponents of resilience assert that the strength of the concept is that it is abstract and malleable enough to be applicable in a wide range of areas (Walker and Cooper, 2011). However, it is not quite clear what is meant by resilience, beyond the assumption that it is good to be resilient (Reid and Botterill, 2013). The scope of resilience has noticeably broadened as it has transitioned into the vernacular of sustainability science (Xu and Marinova, 2013), and there are now more than 70 different definitions of "resilience" in the literature (Fisher, 2015). This begs the question of whether its abstraction is truly deliberate, or whether it is in fact the result of a lack of agreement on what the term actually means (Hodgson et al., 2015; Welsh, 2014). Whatever the reason, the current conceptual discourse on resilience can best be described as being in a state of "Babylonian confusion" (Janssen and Ostrom, 2006), with multiplying meanings of *resilience* that bear only superficial resemblance to each other. Furthermore, the most pertinent issues surrounding climate change (such as surprises, uncertainty, feedback mechanisms etc.) are already being explored and analysed in scientific research without necessarily appealing to the idea of resilience (Batabyal, 1998). These issues elicit questions of whether the concept of resilience actually provides any added value for policy-makers tasked with developing climate change adaptation measures, or whether it is simply an attempt at packaging "new wine in old bottles" (Alexander, 2013).

In part because resilience, as a system property, emerged from the field of ecology (Holling, 1973), little thought is given in the literature to the effect that contextual factors and social dynamics can have on both the formulation and implementation of policies. This omission is especially worrisome considering that resilience is intended, and in some cases is already being used, to guide policy-making. An example of a contextual factor is that social systems - unlike natural ones - have political processes that affect individuals' behaviour, and resilience literature currently does not fully take into consideration the impact that power, politics, and formal institutions can have on overall system behaviour. Additionally, in resilience literature, adversarial relations pitting stakeholders against each other is considered to be a consequence of conventional policy practices rather than a fundamental dynamic of societies (Armitage et al., 2009). The possibility that people may desire many competing and incompatible outcomes is not sufficiently explored in resilience literature, where the assumption seems to be that what is good for the system as a whole (for example ecosystem preservation) supersedes other policy goals (Gunderson, 2010).

Given the issues of conceptual ambiguity and insufficient attention to the particularities of social systems, it is unclear what the added value of resilience is for practical policy-making. Perhaps nowhere is the issue of added value more pertinent than in the field of flood risk management (FRM). Flooding is an appropriate topic because firstly, the Climate Change Risk Assessment (CCRA) conducted by the Committee for Climate Change (CCC) identified increasing frequency and severity of flooding as the main anticipated challenge brought on by climate change in the UK (CCC, 2015). Average annual rainfall - one of the major contributory factors to inland flood risk in the UK - has increased by an estimated 9% over the past twenty years, which has contributed to an increase in more severe events (Marsh et al., 2016). Furthermore, aside from being a highly current topic, FRM is also an uniquely appropriate field to test the added value of a resilience approach since many methods and ideas in modern FRM overlap with those of resilience-based approaches, especially the greater emphasis on partnership approaches (Biggs et al., 2012), and eschewing strictly technical, engineered, solutions to environmental issues (Walker and Salt, 2006). In fact, use of natural flood management (NFM) methods - management that focusses on non-intrusive measures that work with natural processes - have steadily increased in modern FRM initiatives. Within flood management research, NFM used to counted as a sub-set of semi-structural measures, and the UK in particular has made concerted efforts to introduce NFM and other less engineered methods of managing water and reducing flood risk (Green et al., 1993; Smith and Ward, 1998; Tempels and Hartmann, 2014). The similarities between NFM and resilience-based approaches makes the UK especially suitable for studying how principles of resililience can be applied in practice, which might in turn give insights into what added value resilience can provide for practical policy-making. With this in mind, the purpose of my research is to empirically study whether resilience is a practicable concept, that can add value through new insights for policy-making, when applied to the field of FRM in the UK.

I will focus my research on the core distinguishing aspects of resilience, which I have divided into a procedural component, and an evidential component (e.g. evidence-based practice). The procedural component concerns how resilience envisions the policy process and *how* policies are formulated, and consists of *learning and experimentation*, as well as participatory methods. Meanwhile, the evidential component of resilience consists of the information (indices and other measurements) used to better understand the underlying problems, and help justify *why* particular policies are needed. The research is structured in the following manner:

Chapter 2 gives a review of resilience literature, detailing theoretical developments from its origins to current research. I also expand on the literature review by identifying potential questions arising from existing resilience theory.

Chapter 3 focusses on learning and experimentation, which is one facet of the procedural component of resilience. The objective is to determine if *learning*, as conceptualised in resilience literature, is feasible in a practical policy context. This is done by studying how learning comes about during the practical implementation of two experimental pilot projects that incorporate multiple NFM measures, and whether it resembles the learning process envisioned in resilience literature.

In chapter 4, I analyse the practicability of a participatory method, which is another facet of the procedural component of resilience. The objective is to examine if particpatory bodies are indeed capable of improving information-sharing, diversify stakeholders' perceptions, and induce behavioural changes (such as greater self-reliance) as theorised in resilience literature. These issues are studied using a two-pronged approach, first by carrying out a desk study of meeting documents of local participatory bodies, and secondly by surveying local residents who are likely to participate in these participatory bodies.

Chapter 5 and 6 focus on the evidential component of resilience, by studying how the concept is currently measured. The objective is to determine whether current resilience measurements can offer added value by providing new insights for policy-makers in the field of FRM. Taking the 2013/14 and 2015/16 Winter floods in England as test cases, I use statistical modelling to analyise whether indicators frequently used in resilience measurements are effective at predicting flood recovery. Chapter 5 gives an overview of the method, while chapter 6 summarises the results analysis.

Finally, Chapter 7 presents a summary of the findings and some concluding remarks.

Chapter 2

Literature review and theory

2.1 Introduction

This chapter is divided into three sections, with the first two sections presenting a chronological history of resilience – as used in the study of coupled human-nature systems – detailing theoretical developments from its origins to how it is conceptualised today. The final section expands on the literature review by identifying potential issues with existing resilience theory. These further theoretical thoughts are meant to act as primers for the following chapters, which will explore the identified issues in more depth.

2.2 Conception - from descriptive property to theoretical framework

2.2.1 Origins of resilience

The Oxford English Dictionary defines resilience as (i) the act of rebounding or springing back and (ii) elasticity. The origin of the word is in Latin, where *resilio* means to jump back. *Resilience*, in the purely mechanical sense, is the quality of being able to store strain energy and deflect elastically under a load without breaking or being deformed (Gordon, 1978). However, since the 1970s the concept has also been used metaphorically to describe the ability of systems that undergo stress to recover and return to their original state. The term is currently used in multiple fields of study, from Ecology (Morecroft et al., 2012), to Material Science (Campbell, 2008), Medicine (Torres et al., 2016), and Psychology (Gavidia-Payne et al., 2015). Timmerman (1981) was one of the first researchers to apply the term to the study of the interaction between society and nature, and he defines resilience as the measure of a system's capacity to absorb and recover from the occurrence of a natural hazard. However, the researcher who has arguably had a more notable impact on contemporary research into the resilience of human systems (Gaillard, 2010; Xu and Marinova, 2013) is C.S Holling, who in his paper on systems ecology theorised that:

> *"Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist. In this definition resilience is the property of the system and persistence or probability of extinction is the result".*

(Holling, 1973)

This definition of resilience attempts simply to describe a property exhibited by particular ecosystems that undergo extreme fluctuations. Here, resilience can be understood as an approximate measure of the likelihood that a system will survive/persist through internal or external stressors. Hence, the resilience of a system is consistent with low stability for some of the component populations of the system because emphasis is put on the survival of the system as a whole over its component parts (Common and Perrings, 1992).

Holling's initial conceptualisation of resilience has its epistemological roots in evolutionary biology, and is strongly influenced by cybernetics research at the time. His view of resilience essentially considers a system to have a closed signalling loop, meaning any action by a system that changes the environment in which it exists will be reflected – through feedback mechanisms – thereby triggering a change in the system as well (Ashby, 1963). Importantly, Holling seems to have been influenced by the dominant thought at the time that negative feedback mechanisms leads to system organisation, while positive feedback mechanisms[1] leads to system disorganisation and eventual destruction (Dyke and Weaver, 2013). Consequently, his conceptualisation of resilience followed the theory that organised systems had self-corrective mechanisms in place that steer the system back towards an optimal (or equilibrium) state whenever external stressors act upon it. Examples of other cybernetic systems that sense changes in external conditions to maintain stable internal functioning include: homeostasis of an organism, thermostats in homes, and auto-pilots on airplanes or trains.

[1] An example of a negative feedback loop would be perspiration to regulate body temperature, whereas a positive feedback loop would be the concentration of greenhouse gases in the atmosphere accelerating further warming at the Earth's surface

Other researchers have questioned the assumption that human systems (e.g. societies) have an equilibrium state to which they return after perturbations (Klein et al., 2003). In fact, Timmerman (1981) argued early on that pursuing an equilibrium state is “a strategy of reliability rather than a strategy of resilience”. Others note that maintaining equilibrium states requires stabilising, negative feedback loops to predominate over destabilising, positive feedback loops (Dyke and Weaver, 2013). While this type of systems behaviour can be observed at smaller scales (homeostasis in an organism), it is doubtful whether such mechanisms can scale up to significantly more complex systems.

2.2.2 Resilience and complexity theory

Almost at the same time that Holling’s seminal work on systems resilience was published in 1973, the field of cybernetics was already moving on from the “science of observed systems” to “a science of observing systems” (von Foerster, 1992). An observing system does not merely regulate parameters to maintain a static internal environment, but also incorporates “the observer” (e.g. human beings) into the equation. This means that those who designed the system must also be governed by it. Dovers and Handmer (1992) for example, point out that a major difference between ecosystems and societies is the human capacity for anticipation and learning, and since human beings can adapt to external stimuli, this would require that the governance system also be adaptive and can change its basics structure. Essentially, the challenge of understanding and designing an observing (or adapting) system is how to account for human subjectivity.

Perhaps in recognition of the limitations of a system equilibrium approach to conceptualising resilience, Holling and other like-minded scholars partook in a 5-year collaboration programme called the “Resilience Project”, that was organised under the auspices of the Beijer Institute in Stockholm in the mid 1990s (Holling, 2001). The collaboration consisted of an international group of economists, ecologists, social scientists, and mathematicians, whose goal was to find an “integrative theory” that includes “the essence of ecological, economic, and social science theory” (Gunderson and Holling, 2002; Holling, 2001) that could be used to guide policies for promoting sustainability. The search for an integrated theory was motivated by the fact that each discipline only represented one, partial, part of reality and are incapable of individually making sense of social systems as a whole (Holling, 2003). They were then seemingly attempting to find the social equivalent of a “Grand Unified Theory”. The involvement of the economists and mathematicians was of particular importance for ensuing theoretical developments of resilience as well as the conceptual frameworks used to anchor it in social contexts.

The contributions from economic theory consisted mainly of criticism of the dominant economic growth paradigm that guides economic policy and resource use. Their argument was that existing "command-and-control" policies gave insufficient consideration to how (unsustainable) resource management practices could potentially impact societies (Berkes et al., 2000). "Command-and-control" in the context of resilience does not refer to the use of legislation and regulatory tools (such as standards and compliance requirements) to govern economic activity. Rather, it is a term used to describe what those working on the "Resilience Project" referred to as a "pathology of natural resource management" (Holling and Meffe, 1995), where arguably too much focus was being put into optimising for resource efficiency. One oft-criticised example of a traditional "command and control" approach is the Maximum Sustainable Yield (MSY) practice for agricultural production, where the objective is to achieve as much production as possible given existing environmental conditions. It was argued that by only focussing on achieving as much production as possible, the system would be poorly equipped to handle issues such as soil degradation, vulnerability to disease, and other slowly emergent features (Holling, 1996). Over time, the system would then enter a "lock-in trap" (Allison and Hobbs, 2004), becoming rigid and unable to cope with any changes or surprises that may arise. Therefore, rather than focussing exclusively on economic growth or maximum production efficiency, a resilient economic policy would take into consideration uncertainties in the system, and ensure that resource-use never exceeded a system's "carrying capacity" (Arrow et al., 1995) both in the short-term and long-term.

With the economists and ecologists having pointed out that "command and control" economic policies fail to fully take into consideration uncertainty, the mathematicians were then tasked with creating a framework that could be used to guide the decision-making process. This is where complexity was introduced to the *integrative theory*. Complexity, as applied to social systems, is the idea that the risks for an entire system and the risks for individuals within that system may not always align (May et al., 2008). Therefore, actions taken by individuals and policy-makers may not have the intended outcomes. It is basically a formalised way to explain that the whole is more than the sum of its parts. A general definition is that it is a system "in which agents or elements that compose the system interact non-linearly, and in such a convoluted way that it is impossible to describe the behaviour of the system in terms of the simpler behaviour of its components" (Baranger, 2000). Non-linearities, self-organisation, and emergence are three complexity concepts that have particular importance for the theoretical development of resilience. Non-linearity simply refers to cases where there is disproportionate cause and effect, which means that it is impossible to accurately predict outcomes because the outputs of an interaction do not necessarily correspond linearly (1 to 1) to the inputs. Self-organisation in complex systems implies that order is not determined by central control, but materialises through synergies of the whole group. While emergence simply means that collective system behaviour is impossible to predict from behaviours of the individual parts. Self-organisation and emergence are relevant for operating within complex systems because they add uncertainty – that grows exponentially with time – which increases the chance of errors in our predictions of potential outcomes (Goldenfeld and Kadanoff, 1999).

Originally, Holling's descriptive definition of resilience concerned only the ability of an ecosystem to persist. The complexity of a system was largely inconsequential as the properties determining its resilience were not entirely tied together with the number of variables involved. A simple system could be equally (or more) resilient than a complex one, and vice versa. However, it is improbable that a human-nature system can be governed without accounting for complexity. As Marchezini et al. (2017) point out:

> *"institutions, households, and other entities (natural and human-made) function on different temporal and spatial scales. Political electoral cycles, business cycles, life cycles... all of these have a rhythm... and decisions made in national captitals thousands of kilometres distant affect [people living elsewhere] in the form of information flows, price fluctuations and geopolitics"*

The uncertainties arising from non-linear interactions and self-organising, emergent system behaviours, required any attempt at an *integrative theory* for resilience to incorporate complexity theory to the study of coupled human-nature systems. Subsequent theoretical developments of resilience therefore abandoned any delineation between the two concepts, and became primarily focussed on incorporating complexity concepts into resilience theory.

The outcome of the 5-year collaboration project is *Panarchy* (Gunderson and Holling, 2002). Panarchy is essentially a resource-cycle heuristic that emphasises renewal and re-organisation. It attempts to rationalise the interlinking elements of human-natural systems by describing it as continuously undergoing an adaptive cycle of "growth, accumulation, re-structuring, and renewal" (Gunderson and Holling, 2002). The heuristic is largely influenced by elements of complexity theory such as: diversity, individuality of components, localised interactions, and autonomous processes (Levin, 1999; Levin et al., 1998). The theory states that as a system grows increasingly productive and efficient, it also becomes increasingly vulnerable due to rigidities being introduced into the system. At this point, any unexpected stimulus (e.g. natural catastrophe) causes the system to collapse, forcing it to re-organise itself and start a renewal process, whereby the cycle re-commences. Resilience, as described in Panarchy, necessitates embracing uncertainty and unpredictability because sudden changes are inevitable in systems of people and nature (Davidson-Hunt and Berkes, 2003). As such, the aim of resilience is to nurture and preserve elements that allow the system to renew and reorganise itself (Allison and Hobbs, 2004; Walker et al., 2004) in order to avoid collapse as a result of external disturbances. Here, it appears that the authors have borrowed the term *panarchy* from the field of international relations to draw parallels between natural and human subjects. Like *panarchy* global governance, the system envisioned by the authors exhibits no central control, but is rather governed "of all by all and for all" (Sewell and Salter, 1995). At this point, systems resilience evolved from simply being about persistence to also incorporate "adaptiveness, variability, and unpredictability" (Holling, 2001). Also of note is that the authors consider the adaptive-cycle heuristic to not only apply to ecosystems, but social systems as well (Walker and Cooper, 2011).

It should be noted here that the incorporation of complexity theory is in some sense a case of the "Resilience Project" catching up with developments in other fields related to cybernetic research. For example, Nobel Prize winner Ilya Prigogine formulated in the 1970s that processes promoting disorder and disorganisation as not necessarily destructive, and that new structures can evolve out of fluctuations. For societies, this translates to perturbations (e.g. disasters) not only having destructive consequences, but also offering opportunities to rebuild and "to enact beneficial changes that might not have been feasible otherwise" (Kelman, 2007). *Panarchy*, therefore, can be seen as an attempt to incorporate evolving systems theories into Holling's original conceptualisation of resilience.

2.2.3 Social-ecological systems

Influenced by complexity theory, *Panarchy* entrenched the idea that the only meaningful way to understand human-nature systems is by treating them as complex adaptive systems (CAS) (Anderies et al., 2004; Norberg and Cumming, 2008), where each component cannot be studied in separation from the whole. Attempting to do so would only lead to erroneous conclusions (Folke, 2006; Walker et al., 2006) because these systems are inherently variable, uncertain, and prone to change in unexpected ways. To distinguish this branch from studies of complex systems in other fields, the term socio-ecological systems (SES) was coined to refer to the study of resilience of integrated human-nature systems (Anderies et al., 2004; Walker et al., 2004). With the increasing influence of complexity theory, the core ideas of self-organisation and emergence gradually came to dominate the conceptualisation of resilience.

With the growing influence of complexity, resilience literature encountered a dilemma. While they had created a working theoretical framework that helped describe in detail how coupled human-nature systems might behave, little headway had been made in making resilience more actionable. The SES branch of resilience research had hitherto focussed almost entirely on the natural system, with social systems being mostly an afterthought. There was a growing realisation that although systems may self-organise, “the capacities and intent of the human actors strongly influence” the trajectory of the system (Walker et al., 2004). They had essentially encountered what Dovers and Handmer (1992) among others had identified as an issue quite some time: human subjectivity. To account for the human capacity to interpret our environment and act upon these interpretations, resilience literature incorporated elements of anticipation, learning, and reason into the overarching idea of “adaptation” (Liu et al., 2007; Norberg and Cumming, 2008). With the inclusion of adaptation as a central aspect of resilience, its definition also changed to an amalgamation of:

> *“the capacity of a system to absorb disturbance and reorganize while undergoing change, so as to still retain essentially the same function, structure, identity, and feedbacks”*

(Folke et al., 2010)

> *“the ability to absorb perturbations without changing overall system function, the ability to adapt within the resources of the system itself, and the ability to learn, innovate, and change”.*

(Adger et al., 2011)

At this stage, the strain between Holling’s original conceptualisation of resilience as a stability property, and the new understanding brought in by complexity theory that stability isn’t always achievable (or desirable) became more apparent. The SES branch of resilience was essentially concerned with creating a theoretical framework for identifying critical “controlling processes” (Longstaff, 2009; Nelson et al., 2007) that could be used to determine the “planetary boundaries” (Rockstrom et al., 2009) within which society could operate without fear of causing catastrophic environmental change (Westley et al., 2011). The attempt to describe macro-scale boundaries of our Earth, while at the same time allowing for disruptive change at other scales, has led to some terminological confusion that remains largely unresolved. Because of the diverging focus on both maintaining system organisation, while simultaneously espousing the need for system re-organisation, there still is no clear answer to the question: “resilience of what, to what?” (Carpenter et al., 2001). Despite significant advances in creating a comprehensive conceptual framework of resilience, there is very little development in creating practical policy instruments or strategies for enhancing resilience in a system. This begs the question of whether too much effort had been put into creating a concept that would be useful in all circumstances, since it is highly doubtful whether any general rules for the functioning of environmental systems even exist (Bodin and Wiman, 2004; Boettiger and Hastings, 2013).

Furthermore, SES resilience strongly espouses a long-term perspective for managing human-nature systems, with a particular emphasis on looking at a problem from multiple-scales (Armitage and Plummer, 2010). However, complexity theory dictates that adding components and increasing time-horizons lead to greater uncertainty and less reliable decisions (Goldenfeld and Kadanoff, 1999). For example, a meteorologist’s prediction of the weather in London in an hour’s time is likely to be significantly more accurate than their estimate for what the weather in the whole of the UK will be like a year from now. As such, actionable advice on what interventions are needed to enhance resilience will necessarily need to have limitations (of time, space, and relevant components). Yet putting such limitations on decision-making contradicts the edicts of long-term and multi-scalar perspectives (Adger et al., 2005; Boyd, 2012). These contradictions in how the SES branch applies complexity theory remain largely unexplained.

Some have posited that the solution to the dichotomy between stability and change when defining resilience is to simply eschew recovery and “bouncing back” since these concepts discount the fact that perturbations are almost inevitably accompanied by change (Manyena et al., 2011). Instead of recovery, Manyena et al. (2011) suggests that the notion of “bounce forward” is a more suitable way to conceptualise resilience for human-nature systems. In his “bounce forward” theory, Manyena espouses that practitioners and other stakeholders adopt proactive approach and continuously adopt policies ang governance structures to changing risks and the needs of the communities affected by disasters. Resilience by “bouncing forward” necessitates that the choices made after a disaster are transformative and represents a shift in thinking of those involved (Manyena et al., 2011). Basically, the idea is that policies should not be focussed on “doing less bad” (i.e. prevent or mitigate the impact of disasters, and to recover to the original state as much as possible), and instead on “doing more good” (i.e. improve the circumstances of those affected by disasters by changing fundamental policies and structures) (Birkeland, 2012). This is the preferred conceptualisation of resilience amongst those studying disaster risk reduction (DRR) and vulnerability, which will be discussed further on in this chapter.

2.3 Transfer to policy discourse - operationalising resilience

2.3.1 Catalysts of current resilience research

Starting in 2005, there was drastic growth in the number of research publications that dealt with the topic of resilience (Xu and Marinova, 2013), and as a result of the growing interest, resilience research expanded in scope and entered the vernacular of a wider variety of disciplines. Two publications that served as notable catalysts that spurred the popularisation of the concept, and aided its adoption within policy circles are:

a) Creation of the United Nations Office for Disaster Risk Reduction (UNISDR) Hyogo Framework for Action in 2005

The Hyogo Framework is most noteworthy for being the first global policy document that uses the term “disaster resilience” to describe a concept that up until then had mostly been referred to as Disaster Risk Reduction (DRR). The framework called for the “integration of disaster risk considerations into sustainable development policies” and advocated for strengthening “capacities” across all levels, particularly “at the community level” (Hyogo, 2005). By emphasising sustainable development, and the empowerment of communities and local authorities, the framework was a starting point for popularising the use of resilience concepts amongst a wider audience of policy-makers. The Hyogo Framework also put greater emphasis on the role of international development objectives such as vulnerability reduction and poverty alleviation, which the SES branch of resilience had hitherto only given cursory consideration to (Adger, 2000; Adger et al., 2005). In essence, the Framework served as a useful synthesis document of the resilience concept up to that point, and helped guide the direction of future research by emphasising some key issues that have become more prominent within resilience research.

b) Revision of the US Department of Homeland Security’s National Strategy for Homeland Security in 2007

American contingency planning had focussed mostly on counter-terrorism and homeland security after the events that transpired on 9/11. But in the aftermath of the Indian Ocean Tsunami in 2004 and Hurricane Katrina in 2005, it was decided that a course correction on priorities would be needed, which resulted in the revised National Strategy for Homeland Security published in 2007. The new strategy was notable for insisting that none of the threats to infrastructure, communities and institutions were fully preventable (Walker and Cooper, 2011). It therefore proposed that in lieu of prevention, contingency planning needed to focus on "operational resilience" (USDHS, 2007). In practice, this meant that emergency planning and response would focus on preparedness for any potential threats (natural and human-induced) rather than a single one. A secondary aim was also to change public mentality from safety, to readiness and being prepared for anything (Coaffee and Rogers, 2008). The dual goals of shifting to multi-hazard disaster preparedness, and assigning greater responsibility to communities and individual citizens happened to align smoothly with principles of complexity and self-organisation mentioned in resilience literature. As the Hyogo Framework helped cement the importance of vulnerability reduction and poverty alleviation, so did the DHS National Strategy aid in giving multi-hazard preparedness and individual self-reliance central roles in resilience discourse. These ideas would become core principles of current conceptualisations of resilience.

2.3.2 Current definition of resilience

The transfer of resilience from a theorised property of human-nature systems discussed in academic circles, to a concept used to inform policy making, resulted in an expanded use of the term that has seen its definition become increasingly vague. This increasing ambiguity of resilience is partly due to the inherent contradictions within the current conceptualisations of resilience, where emphasis is placed on both stability and change. Holling (1996) partly attempted to clarify this dichotomy by separating what he called "engineering resilience" from the SES approach. Holling's use of the term should not be confused with its use in the field of engineering however, where it is mostly considered a mechanical property used to measure material elasticity (Campbell, 2008). In resilience literature, "engineering resilience" refers to a management perspective that focusses on efficiency, and regulates systems so that they remain near a pre-determined equilibrium. The main difference between the two branches of resilience can briefly be summarised by the explanation that engineering resilience emphasises "bounce-back" or "recovery ability" (Norris et al., 2008), whereas SES - by incorporating elements of complexity theory - highlights re-organisation and adaptation (Leichenko, 2011). Combining these two branches allowed a much more comprehensive cover of potential risks, where the resilience concept would be applicable to both currently known risks (historical conditions), as well as future unpredictable risks (changing conditions). Currently, one of the most widely used definitions of resilience is:

> *"(Resilience is) the ability of a system, community or society exposed to hazards to resist, absorb, accomodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions".*

Source: (UNISDR, 2009)

Key determinants of resilience in its current conceptualisation include: a) adaptive capacity, b) multi-level governance and participation, and c) vulnerability (Cutter et al., 2014; Frazier et al., 2013; Leykin et al., 2013).

a) Adaptive Capacity

As mentioned in section 2.1.3, adaptation is used to reconcile the concepts of emergence and self-organisation with particularities of human societies such as rules, norms, and institutions etc. Due to the current conceptual ambiguity of resilience, there is no general agreement on some basic questions regarding adaptation such as: "capacitiy of what to adapt?", "who adapts?", and "how and for what purpose does adaptation take place?" One of the main branches of resilience literature conceptualises adaptation as a learning process that comes about through a deliberate, experimental approach (Armitage et al., 2009; Becker et al., 2015; Folke et al., 2005; Gunderson et al., 2008). They argue that since human-nature systems are inherently variable and prone to change unexpectedly, adaptation through a deliberate process of experimental probing and learning is the only viable approach to account for complexity (Evans, 2011; Walker et al., 2009). This conceptualisation envisions nature as the primary cause/driver of change, and human societies are required to adapt to these external drivers of change (Turnbull et al., 2013; Walker and Salt, 2006). Adaptation is argued to be most achievable through adjusting relevant management practices and policy tools, by incorporating newly acquired knowledge that relevant stakeholders have learned through experimental initiatives (Chang et al., 2014; Reyers et al., 2015; White et al., 2015). In this conceptualisation, an adaptive management process would be:

Perturbation > Learning > Knowledge acquisition > Adaptation > Resilience

In practice, the proposed experimental approach to adaptation entails a management process that "integrates scientific knowledge into policy-making in an on-going, recursive learning cycle" (Voss and Bornemann, 2011). Policy planning and implementation is understood as a hypothesis testing exercise (Ahern, 2013), where policy-makers, scientists and other stakeholders come together to co-produce new knowledge that will guide future policy-making (Evans, 2011). The underlying assumption of this approach is that "failure is a statistical inevitability for any system" (Hollnagel et al., 2006). Since perturbations that cause damage to the system are inevitable, effective management under a resilience approach requires policy-makers and stakeholders to shift "from a mindset of fearing change" to embracing it (Chapin III et al., 2009; Park et al., 2013). Embracing change translates into viewing disruptions not as something to be avoided, but rather as necessary to achieve resilience (Blann et al., 2003; Liao, 2014). It is implied that learning and adaptation can only take place by experiencing perturbation (Becker et al., 2015; Gunderson, 2010), and some have even suggested that each disaster "that is prevented is a loss of opportunity for learning" (Liao, 2012). Basically, recursive learning is about making systems "safe-to-fail" by accepting failure as inevitable rather than something to be avoided (Ahern, 2011). It is believed that practitioners can learn more by allowing "modest failures" (Park et al., 2011) to take place, which will make them better at preparing and adapting policies that are capable of dealing with potentially catastrophic failures.

Adaptive capacity, as described above, is very similar to the concept of "bouncing forward" developed by Manyena et al. (2011), and the argument that change and disruption does not necessarily have to lead to purely negative consequences. An underlying principle is that the "secret to safety lies in danger", and in order to become resilient, society needs to foster a process of continuous learning to maintain creativity (adaptability), that strikes a balance between order and chaos (Comfort, 1994).

b) Multi-level governance and participation

A core argument within resilience literature is that "centrally administered bureaucracies are ill-suited to managing complex social-ecological systems" (Becker et al., 2015). The reason for this is that policies from central authorities tend to be rigidly standardised with little consideration for local conditions and contexts (Cavallo and Ireland, 2014). Conventional management methods are also argued to be less capable of handling the dynamic nature of various threats facing societies because they take insufficient consideration to long-term system trends (Jabareen, 2013). Since effective management requires a thorough understanding of local conditions as well as current and future risks (Jha et al., 2013; Turnbull et al., 2013), a "bottom-up" approach is needed to fully deal with the full range of hazards that a system can be exposed to (Wardekker et al., 2010).

According to current resilience research, an ideal governance structure for dealing with uncertainties is polycentric, applied at an appropriate scale, and features participatory management (Becker et al., 2015). This is because strictly focussing on larger-scale, institutional stakeholders will give a biased understanding of the issues, and one risks missing out on the influence of more micro-scale actors (Marchezini et al., 2017). Since local authorities and stakeholders arguably understand their risks better, empowering them will tap in to local capacities and resources that can be crucial for effectively managing unexpected changes (Folke et al., 2005). Therefore, a collaborative "bottom-up" approach that focusses on building local capacities will result in a more resilient society that is better able to overcome future disturbances (NRC, 2012; Toubin et al., 2014).

c) Vulnerability

Interestingly, while scholarly debate on resilience have taken place both in the field of ecology and DRR over decades, theoretical developments have largely been done independently of each other until quite recently (Cutter et al., 2008; Menoni et al., 2012). Where attempts have been made to integrate the two fields, it has generally been assumed that resilience is a subcomponent of the *risk* umbrella, which includes other concepts such as vulnerability (Fekete et al., 2014). As with resilience, the concept of vulnerability is elaborated in a multitude of research disciplines ranging from geophysical sciences to psychology. Importantly, it has become a core concept in hazard and disaster risk reduction (DRR) research (Blaikie et al., 1994; Burton et al., 1978; Hewitt, 1983; O'Keefe et al., 1976; Wisner et al., 2004). A full account of the various conceptualisations of vulnerability within DRR is beyond the scope of this study, but crucially, the predominant view in DRR is that the interaction between hazard, exposure, and vulnerability constitutes risk (Gallopin, 2006; Wisner, 2011). Hazards can mean natural, technological, or other processes that can endanger people, while exposure – in the case of natural hazards – usually means that people living in certain locations are more likely to suffer loss and harm. Vulnerability meanwhile, can be understood as the propensity to be harmed (by a hazard), and to be unable to deal with that harm. It is a term – when used in DRR – that encompasses a society's values, attitudes, behaviours and governance structures (Kelman et al., 2016). It puts the onus on human decisions, rather than the hazard phenomena, as the root causes of disasters (Alexander, 1997), and therefore strongly links poverty as a significant factor of disaster causation (O'Keefe et al., 1976). The reasoning is that disasters are more impactful for the poor due to prolonged loss of income, whereas for the rich these events are "more often an inconvenience than a personal tragedy"

(Alexander, 1997) due to the possibility of, for example, insurance coverage. There is some terminological confusion concerning how resilience fits into the "umbrella" of risk (Aldrich and Meyer, 2015; Gaillard, 2010), where some have argued that resilience is essentially a synonymous term to response capacity (Wagner et al., 2014), but others see it more as cohesiveness and coping capacity (Balica and Wright, 2011; Hinkel, 2010). There seems to be general agreement however, that hazard risks cannot be reduced by focussing solely on infrastructural and technical solutions (Birkmann et al., 2013).

The reason why targeted infrastructural or technical solutions are considered inadequate is because they are predicated on an assumption about there being a normal - or stable - state in which society normally operates (Hewitt, 1983). The risks posed by natural hazards are therefore arguably mainly the result of human decisions, such as "acting on a false sense that 'risks of nature' have been dealth with" (Hewitt, 1983), rather than the hazars themselves. For example, it is well known that the Mexican Gulf area suffers from hurricanes annually, therefore if society suffers catastrophic damages then this would seemingly be due to decisions that have been made rather than the fact that there are frequent storms. Since the consequences of disasters are the result human decisions rather than environmental factors, it is asserted that measures aimed at reducing vulnerability through improving socio-economic factors would be the most effective options for overcoming any potential disruption (Cutter et al., 2008). Factors such as social connectedness, and community social capital in the form of mutual resources and support are considered crucial elements because they contribute to the ability to self-organise after disruptions (Peacock et al., 2010; UNISDR, 2012). With an increased ability to self-organise, there will consequently be less need for policy interventions from central governments. Furthermore, because resilience literature considers system failure to be an inevitability, it is argued that improving people's self-sufficiency would be more beneficial in the long term than giving them a false sense of security (Boon, 2014).

2.3.3 Operationalising resilience

The expanding theoretical framework and conceptual ambiguity of resilience is reflected in the widely ranging attempts at operationalising resilience at national levels. Taking a sample from the spectrum of national resilience strategies, they all adopt a similar definition of resilience. However, the methods and objectives for their resilience initiatives differ widely. There seems to be general agreement amongst policy practitioners that resilience refers to a society's ability to prepare for, persist through, and recover from unexpected disruptions (such as natural disasters). But the exact nature of these disruptions varies a great deal, which is reflected in the detailed policies promoted within these national strategies. A number of examples are discussed below.

Australia (2011) – National Strategy for Disaster Resilience: Emphasises climate change and multiple kinds of potential disasters such as flooding, droughts, wildfires. Because it is difficult to predict which perturbation is relevant, the strategies focus on community preparedness and promoting self-reliance.

Canada (2016) – National Disaster Mitigation Program: Primarily concerned with flood risk, therefore focusses on reducing the impact of flooding by ensuring that critical infrastructure (energy, water, health provision, transport, telecommunications) can persist and function through flooding.

Japan (2013) – Fundamental Plan for National Resilience: Focusses specifically on earthquake response. The onus of suggested measures is on limiting damages to vital infrastructure, and increasing capacity to recover from earthquakes and building overall response capacity to ensure that things go back to normal as quickly as possible.

Sweden (2015) – Making Cities Resilient in Sweden: Refers mostly to flood risk management and ensuring that critical infrastructure in cities is able to function throughout the event. Also mentions the need to build up community awareness and preparedness.

NFRR (2016) – National Flood Resilience Review: As the report name suggests, resilience in the UK primarily refers to flooding. As with Canada and Sweden, the proposed measures mainly focus on ensuring that critical infrastructure is able to persist and function through flooding. The UK also developed a Strategic National Framework on Community Resilience (2011), which emphasises public security and emergency response capabilities. Unlike resilience strategies from other countries, this strategic framework gives particular emphasis to man-made threats.

FEMA (2012) – FEMA Crisis Response and Disaster Resilience 2030: Forging Strategic Action in an Age of Uncertainty: This is the broadest of all national resilience strategies, covering public safety and disaster management. The document is meant to assist planners for both man-made and natural events. As in the case with Australia, the strategy is meant to apply to a wide variety of potential threats, and therefore the proposed measures highlight the importance of public engagement, community readiness, and building local capacities.

Looking at the sample of national resilience strategies, it seems that the conceptual ambiguity of resilience has resulted in individual practitioners being responsible for finding suitable definitions in order to operationalise the concept. These definitions, along with the accompanying suggested policy measures, strongly reflect the particularities of the problems that these practitioners are trying to solve. For example, in cases where practitioners are concerned with a specified threat (earthquake for Japan, flooding for Canada, Sweden, and UK), strategic priorities focus on critical infrastructure and their ability to function during, and after the disaster. Australia and the U.S. on the other hand, use resilience as a guiding principle of crisis management, putting emphasis on improving community preparedness and self-reliance, with the implicit assumption that authorities are unable to sufficiently plan for all possible contingencies. With this in mind, it would be pertinent to question whether the concept of resilience has become too general, since attempts to operationalise resilience suggest that it is so terminologically ambiguous that it can mean whatever the author wants it to mean. Despite this growing ambiguity, the enthusiasm for "building resilience" within some areas of DRR remains unabated, with there being an almost unquestioning acceptance that resilience is good and should be promoted (Fekete et al., 2014). This growing ambiguity offers very limited scope for measuring, testing, and formalising resilience, which in turn makes it extremely challenging to create operational tools for policy and management purposes.

2.4 Further theoretical thoughts on resilience

2.4.1 The problematic link between learning and adaptation

One assertion that encapsulates the potential problems with current resilience research is Jack Ahern's claim that: "resilience is a more strategic than normative concept, because, to be effective, resilience must be explicitly based on, and informed by, the environmental, ecological, social, and economic drivers" (Ahern, 2011). This assertion ignores that basic strategic questions such as: "who decides", "who should act", and "who is responsible and accountable", clearly require consideration of issues beyond strictly technical criteria (Wiering et al., 2015). Furthermore, the desirability of a resilience-based approach will vary depending on one's perspective. For example, one of the fundamental disagreements remaining in global climate negotiations is the "right" to produce further greenhouse gas (GHG) emissions, where developing nations have long argued that drastic reductions unfairly restricts their growth potential (UNFCCC, 2004). As such, something that resilience literature would undoubtedly consider to be the "correct" decision, meaning reducing GHG emissions in order to avoid catastrophic climate change, still entails a fundamentally normative judgement; that preventing climate change is of greater importance than ensuring global economic prosperity. Perhaps they are right in assuming this, but it is still quite specious to suggest that resilience does not include broad normative dimensions (Brand and Jax, 2007).

Resilience is considered to be a superior concept to guide management of human-environment systems because it takes into consideration (a) complexity, and (b) the long-term perspective needed to handle unexpected change (Nelson et al., 2007). It may be true that designing for resilience will make societies better able to deal with new challenges; however, foregoing short-term benefits for long-term persistence is not without costs (Anderies et al., 2006). While the need to adopt a long-term perspective in face of multiple uncertainties may seem self-evident for resilience researchers, for policy-makers doing so would require determining: (a) how to design for resilience, and (b) what the costs are (Anderies et al., 2004; McShane et al., 2011). From a policy design perspective, the choice is therefore not as straightforward as picking a superior option over an inferior one. It is about deliberately choosing to alter the objectives of policy-making, and attempting to find effective strategies for managing the accompanying trade-offs (Saleh, 2008).

Acknowledging that resilience entails normative policy design choices is important because its conceptualisation of the learning/adaptation process is somewhat problematic. Firstly, its assertion that the learning-by-doing process is a hypothesis-testing exercise (Ahern, 2013; Reyers et al., 2015), used to pinpoint better management practices, is somewhat speculative. Hypothesis-testing in social contexts, at the scale proposed in resilience literature, is notoriously challenging because of the prevalence of *white noise* factors that can affect outcomes (Orr, 1999). An experimental management process assumes that the effects that policy interventions have on outcomes can be isolated from other contextual factors, and also that practitioners are able to bypass their own personal biases when making policy choices. Given the well-known difficulties of determining intervention-effects in the field of social experimentation (Grogger and Karoly, 2005), and that implicit bias is an established phenomenon in human decision-making (Baron, 2008), it would be highly relevant to question how feasible these assumptions are.

Furthermore, adaptation as conceptualised in much of resilience research is a process akin to evolution (Levin et al., 1998), which is not entirely unproblematic. Chapin III et al. (2009) for example, state that:

> *"Allowing large corporations to fail during economic crises provides space for innovation and adjustment to shifting economic opportunities. Such management that fosters change at one scale might enhance resilience at a broader scale".*

Disregarding the obvious normative parallels between the above quote and *laissez-faire* economics, the implication of constantly having to adapt to changing circumstances is that a resilience approach to policy-making becomes a *Red Queen's race* (Van Valen, 1973). Systems that do not adapt perish, and therefore in order to survive, they are forced to continuously adapt without end. Over time, adaptation becomes a management goal in of itself. As the eponymous Red Queen said in Lewis Carroll's *Through the Looking Glass*:

> "Now, *here*, you see, it takes all the running you can do, to keep in the same place".

The point is that by assuming the evolutionary perspective, the objective of policy-making is not necessarily about enhancing well-being in society, but rather about improving management practices to become better at adapting. Importantly, it is unclear why being adaptive and capable of change will lead to greater well-being for the stakeholders involved. Even through a framework such as "bouncing forward", where positive change is theoretically achieved through co-operation between stakeholders who undergo mutual learning, and pro-actively work to adapt the system to a changing environment, there are key questions that remain largely unanswered. How might we define what constitutes a positive or negative consequence? How can this learning process extract the positive consequences of a disaster while also minimising the negative ones? Is it possible that resilience-building is in fact a zero-sum game, where some stakeholders will inevitably we worse off irrespective of whether a system "bounces back" or "bounces forward"? Having pointed out some of the questions surrounding the experimental, learning-by-doing resilience approach, I will further examine the issues of feasibility in chapter 3.

2.4.2 The muddled conceptualisation of participation and collaboration

Another noteworthy aspect in the conceptualisation of resilience is the sometimes derisive undertones in its treatment of political, cultural and economic factors in the policy implementation process. These factors are sometimes seen as "barriers" to resilience, and in order to achieve desirable outcomes it may be necessary to "circumvent" or "overcome" limitations imposed by them (Moser, 2008; Westley et al., 2011). Hierarchical political structures with significant central authority is especially seen as inimical to resilience, and polycentric, flexible arrangements involving local stakeholders are considered the solution to barriers such as political deadlock or inertia (Davidson-Hunt and Berkes, 2003). A participatory, "bottom up" (Axelrod and Cohen, 1999) approach is viewed as more effective because it arguably ensures more stakeholder buy-in, while simultaneously increasing community capacities (Lorenz, 2013). Increased community capacity means greater "self-reliance" (Davoudi, 2012) in that people are able to deal with disturbances and self-organise rather than relying on government support.

The shortcomings of the participatory management approach espoused in resilience research is that collaboration and participation does not necessarily mean that questions of power and diverging political interests disappear (Kuhlicke, 2013). Assigning the decision-making process to a more participatory arrangement simply ensures that the political debate shifts from an intra-institutional forum to a public one. For example, in a "bouncing forward" process, organising stakeholders in affected communities through mutual learning and a co-operative decision process theoretically leads to positive change. However, this assumes that the stakeholders who participate in the decision-making will agree that change is positive. This may not necessarily be the case since it is quite possible that they act to prevent change instead, due to political or cultural conservatism for example. Simply put, it is never made clear why a collaborative/participatory approach would be better at dealing with surprises and uncertainties - and engender change - than more centrally organised management structures. In fact, the support for participatory methods within resilience literature seems to coincide with the larger societal context, where "stakeholder engagements" are considered "best practice" for supporting policy decisions (Cornwall, 2008; Dunn, 2007). Given these considerations, it would be fair to ask whether a collaborative/resilience approach is truly a required component for building resilience, or whether it has simply been tacked-on as a compulsory element of "good governance". I will explore the practicability of participatory methods further in chapter 4.

2.4.3 The debatable added-value of a multi-hazard perspective

As is mentioned earlier, despite the central role of adaptive capacity within the conceptualisation of resilience, what constitutes adaptation is still subject to multiple and sometimes conflicting interpretations (Bulkeley and Tuts, 2013). This conceptual confusion can partly be attributed to the focus on making resilience a multi-hazard property (Balsells et al., 2015), which has led to a notable lack of specificity and understanding regarding the type of surprises and non-linearities that practitioners need to be aware of (Schlueter et al., 2012). The result is that even when referring to a specific disaster, say flooding, resilience is still defined using general - sometimes contradictory - terms (Toubin et al., 2014). For example, some have asserted that movement of people and displacement is a failure of adaptation (Adger and Adams, 2013). Whereas others have found that mobility and migration can be an indication of high adaptive capacity because of abilities to tap into necessary capabilities and assets (Warner et al., 2013; Wrathall, 2012). Basically, even though they are completely opposite outcomes, remaining in place and moving away can both be considered resilient adaptations.

The problem of lacking an explicitly stated definition for adaptation can perhaps be further clarified with the following hypothetical scenario. Assume that central London were to experience catastrophic flooding, severely damaging all iconic landmarks around the Thames. Once the flooding passes, the Government would have a chance for a fresh start and plan everything from a clean slate. It is also assumed that similar kinds of extreme flooding affecting London will become more likely with climate change. Would it then be considered a great achievement, or one of the most foolish decisions in history, to rebuild and restore the city and its historic landmarks in their original locations? How one answers that question probably depends on a multitude of (highly normative) factors that range widely outside the scope of a simple planning decision on whether to rebuild or relocate. The point is simply that without explicitly stated definitions and delineations, one's understanding of what constitutes adaptation would be highly influenced by normative values and biases

The issues associated with making resilience a multi-hazard property matter not just because it can result in contradictory policies. Focussing primarily on adaptive capacity and treating society as a complex system is also not entirely uncontroversial. Adaptation is said to come about through system self-organisation, but when self-organisation is translated into the social context, there is strong potential for creating ideological overtones to the concept (Davoudi, 2012) (i.e. *laissez-faire*). In flood risk management for example, planning can be broadly understood using the following function:

$$FloodRisk = f(hazard, exposure, andvulnerability) \tag{2.1}$$

Flood Risk means the overall level of threat posed by a flood in terms of potential damage; *Hazard* refers to the characteristics of the flood, its gravity, chance of occurrence etc.; *Exposure* refers to the extent to which people and infrastructure will be affected by a flood; and *Vulnerability* refers to the susceptibility to suffer damages as a result of flooding, due to for example poor housing conditions (Aerts et al., 2013; Lugeri et al., 2010). A flood hazard in a remote, uninhabited part of the Scottish highlands would pose no flood risk for example, since there would be no people or infrastructure exposed to the flood. Therefore, managing the risks of a disaster like flooding can be done by targeting either exposure or vulnerability (Aerts et al., 2014), but a resilience approach focusses almost exclusively on vulnerability. The idea that exposure to disasters is unavoidable may be technically correct from an academic standpoint, but the assertion that self-organisation is more effective than central planning does seem to suggest that resilient people should not look to states to secure their well-being because it will be necessary to secure it for themselves anyhow (Reid, 2012; Welsh, 2014). Some researchers argue that formulating a more explicit definition of resilience and adaptation may lead to practitioners over-simplifying a multi-faceted issue (Chelleri et al., 2015). But lacking details and specificity about what is meant by resilience could also potentially allow highly normative interpretations to take shape, where the concept can be used to abrogate the role and necessity of central government interventions in disaster management for example.

Furthermore, it is not entirely clear why the literature suggests that the best method for enhancing resilience towards perturbations is to focus efforts on socio-economic factors. While non-linearities and self-organisation have been core components of resilience from its conception (Holling, 2001), deliberate policy interventions targeting specific management practices or environmental factors was still believed to the the most effective means of achieving adaptation (Nelson et al., 2007; Walker et al., 2009). One possibility that explains this shift from emphasising targeted policy interventions to the impetus being put on wider socio-economic factors. There has long been an underlying hypothesis in disaster vulnerability research of a strong positive correlation between low socio-economic status and high vulnerability. Or as Blaikie et al. (1994) state: “as a rule the poor suffer more from hazards than the rich”. Furthermore, Hewitt (1983) in his seminal work, states that “’alienation from the land’ through modernisation is integral to the vulnerability of ordinary people”, and the root causes can therefore be found in the social and economic structures that govern society. More to the point, many question “the nature of economic growth and whether it is, as is assumed, necessarily a good thing” (Wisner, 2011).

This begs the question: is resilience a property that describes the ability of a system to withstand disasters, or is it a measurement of a system’s economic equality and degree of social justice? If it is the latter, then is disaster risk planning and management necessarily the most appropriate forum to address these issues? Does it necessarily follow through logically that the best means by which policy-makers can manage for example, flood risk, is to apply policy instruments intended to to alleviate destitution? In chapters 5 and 6, I will further explore the usefulness of incorporating socio-economic indicators into flood risk management, and whether this provides any new insights for policy-makers wishing to improve flood resilience.

Chapter 3

Learning and experimentation

3.1 Introduction

It was noted in the previous chapter that, according to the SES literature, adaptation through an experimental, learning-by-doing process is one of the primary means by which a society can enhance its resilience to perturbations like natural disasters. Considering how strongly connected learning is to adaptation in the theoretical discourse, there is a conspicuous lack of agreement among researchers on what constitutes recursive learning, or how such a process might take place in practice. Existing case studies on learning and adaptation focus primarily on theoretical development and proof of concept rather than exploring how an experimental process can be implemented in practice (Olsson et al., 2010; Schultz et al., 2007; UNDP, 2014; Walker et al., 2009). The few case studies that have analysed experimental processes have found equivocal evidence that it leads to adaptation (Melis et al., 2015; Voss and Bornemann, 2011). Given that the recursive, experimental, approach to learning is highly idealised, the lack of empirical studies begs the question of whether such a learning process is in fact feasible in practice. Seeing as much of current resilience literature is aimed at guiding and informing policies (Bene, 2013; Boyd, 2012; Jha et al., 2013; NRC, 2012), the feasibility of an experimental learning process is of central importance, since a concept that cannot be implemented in practice would provide minimal added-value for policy-making.

With these issues in mind, the goal of this chapter is to determine whether learning, as conceptualised in resilience literature, is feasible in a practical policy context. This will be done by using two Defra-funded experimental FRM pilot projects located on the Holnicote Estate and in Pickering Beck, as case studies. The method of study consists of interviews with relevant policy managers and practitioners, focussing specifically on how learning comes about in a practical policy setting, and whether it resembles the recursive learning process envisioned in resilience literature.

3.2 Background and theory of learning in resilience literature

In SES literature, learning is broadly understood as the process through which society can achieve adaptation. It is a highly deliberate process of recursion that comprises sensing, anticipation, and knowledge-acquisition that eventually leads to adaptation (Ahern, 2013; Armitage et al., 2008; Biggs et al., 2012). The objective of learning, as defined in SES literature, is knowledge acquisition (Olsson et al., 2004; Walker et al., 2006). This knowledge is then useful when applied to change policies and help improve the capacity of a system to adapt to disruptions, thereby enhancing overall resilience. This conceptualisation essentially understands adaptation as synonymous with policy change, which is ideally accomplished through a recursive learning process. This “experimental” framework (Nelson et al., 2007) implies that policy formulation and implementation is constantly in a state of improvement to become better by taking into consideration changing conditions. By putting the onus on policy improvement, it is implied that policy changes are only made when taking into consideration relevant inputs from changing conditions, and all other inputs identified as *white-noise* will be disregarded. Basically, SES literature currently views decision-making as an essentially rational process (Simon, 1977), where problems are tackled through a series of cumulative and logical steps, and choices are made based on good quality information (Turner et al., 2003; Wagner et al., 2014).

As was mentioned in the previous chapter, adaptation is very broadly interpreted. Two wide ranging assumptions are made about the learning process that receive insufficient attention, and put in doubt how feasible it is in a practical context. It is firstly assumed that adaptation comes about through a reactive learning process, where changes are dictated by natural conditions. This conceptualisation fails to acknowledge that societies have many intentionally designed elements that can be difficult to modify. Secondly, it is assumed that policy changes are guided mainly by newly acquired knowledge, with little influence from factors that are not directly related to practical policy implementation. The lack of attention given to these two assumptions make it relevant to question whether a recursive learning process as envisioned in resilience literature is feasible in practical policy implementation.

3.2.1 Intentional design as limitation on learning

A likely reason for the insufficient consideration given to the intentionally designed elements in societies is the strong influence of complexity theory on resilience. A core tenet of complexity is that system order does not come about through intentional planning, but rather through the spontaneous ordering (or self-organisation) that theoretically results from actions of taken by individuals within that system. But what distinguishes social systems from natural ones is that measures are frequently introduced that are intended to alter the overall functioning of the system rather than simply the circumstances of each individual. This means that rather than order exclusively emerging through actions taken by every individual only looking out for their self-interests, societies can introduce actively designed measures (like policies) intended to alter the entire system. While it is partly correct that emergence and self-organisation do not preclude society from having intentionally designed elements, only that whatever we do will have unintended consequences. It is nevertheless undeniable that because of our capacity for intentional design, adaptation in a social system cannot simply be about passively accepting changing conditions and making needed changes as dictated by external inputs. Having a capacity for intentional design means that societies can actively attempt to alter conditions to better suit our needs. Currently, resilience literature mostly treats policies as tools used to allow societies to accommodate and adjust to changing conditions. However, policies are not just instruments we use to change certain elements of society. They are highly normative, reflecting our fundamental values and beliefs, and are intended to shape society in a way that reflects these values to the furthest extent possible.

The implications of intentional design on the learning process are profound. While learning can be a passive exercise driven by changing external conditions, it can also be an active process that leads to measures being taken that actively reduce, or even neutralise, the impact of external conditions. A clear example of passive and active learning is the different views society holds of natural disasters such as earthquakes or hurricanes on one hand, and river flooding on the other. Passively adapting to earthquakes or hurricanes is feasible because it is widely accepted that there is very little we can do to stop them, or minimise the risk of them affecting societies. Therefore, purely pursuing mitigating measures and simply learning to live with these disasters is acceptable policy. River flooding on the other hand, is not widely viewed as unavoidable, and a passive policy approach that treats floods as inevitable is unlikely to be accepted. In flooding, there is an expectation that policies at least partially be designed to ensure that the risk of floods is minimised. Consequently, learning might not necessarily mean learning to live with floods. It can equally likely mean learning how to manage water so as to avoid flooding altogether.

Simply put, intentional design is relevant because the recursive learning process envisioned in much of resilience literature fails to recognise that the motivation – or *raison d'etre* – of policies matter. The purpose of learning in policy implementation cannot be limited to making better policies, the objective needs to be making policies that are better for society. In essence, learning is not necessarily limited to a process of identifying "universally correct solutions", but rather about finding "viable solutions" among a multitude of possibilities (Yamori, 2008, 2011). Basically, a learning process that is sub-optimal, but feasible within its political and social context, can oftentimes be preferable over an ideal learning process that cannot be fully implemented.

3.2.2 How outside factors can influence the learning process

The idealised, rational, policy learning process depicted in resilience literature strongly resembles the systematic design theory of policy formulation (Alexander, 1982). In systematic design, policy practitioners go through a deliberate search for different options to generate and compare alternative interventions to find the best available choice (Linder and Peters, 1985; Weiss, 1982). In such a scenario, policy changes would only come about as a result of new knowledge being acquired that offer pertinent input for improving the existing policy. But policy-making does not exist in a vacuum, and much of current criticisms against systematic design point towards its tendency to isolate policy decisions from outside factors (Hajer, 2003; Oliver and Lodge, 2003). Factors that can constrict learning include: differing legal codes, cultural sentiments, and governing systems (Dolowitz, 2013); policy bias and bureaucratic politics of involved authorities (Dussauge-Laguna, 2013; Pedersen, 2007); and the economic and technical resources available to support policy programmes (Busenberg, 2001). Basically, even experimental policies are unlikely to begin with a clean slate. New policy interventions have to exist in an established landscape of existing policies and political interests (Kay, 2005) that cannot be ignored by practitioners.

Furthermore, political ideas (Dudley, 2003; Hall, 1993) and a "core-belief system" (Sabatier, 1987) can be deeply important in shaping decisions and driving policy implementation. The normative convictions of stakeholders can be highly relevant across almost all policy domains (Sabatier, 1999). They can put restrictions on the policy choices available to practitioners since certain stakeholders might find some alternatives to be unappetising by virtue of them being incompatible with their belief system. This is especially pertinent to methods – such as adaptive management – that require stakeholders to learn, and change their perspectives throughout the course of programme implementation, since empirical studies show that core policy beliefs tend to remain fairly constant over time (Eberg, 1997; Van Est, 1999). It is entirely possible that if stakeholders' core beliefs are not aligned at the start of a policy programme, then what they learn from policy interventions could be widely different. This is acknowledged in disaster management research for example, where Kates (1962) found very early on that when given the same information, individuals will still have dissimilar perceptions of hazard, and therefore also exhibit different behaviour. Inded, he found that the likelihood of an individual taking action and responding to policy interventions "is heightened by flood experience, and particularly either repetitive experience or those entailing personal loos or effort" (Kates, 1962).

3.3 Overview of case studies

In 2009, as a response to one of the recommendations expressed in the Pitt Review of the Summer 2007 floods (Pitt, 2007), Defra commissioned three Multi-Objective Flood Management Demonstration Projects. These projects were intended to be highly experimental, with little guidance provided by Defra for how implementation should go about or what the project targets were. The project leads were therefore free to choose whatever means they deemed fit as long as they could provide tangible evidence of how their measures impacted flood risks. One requirement however, was that projects had to specifically demonstrate how working with natural processes, using natural flood management (NFM) measures, and adopting a partnership approach could contribute to reducing flood risk. NFM refers to specific FRM techniques that are meant to work with natural hydrological and morphological processes, rather than control them the way that engineered flood defences (dikes, flood-wall, levees etc.) do. Examples of NFM techniques include river restoration, wetland enhancement, alteration of riparian land etc.

These pilot projects are especially suitable for studying the feasibility of the learning process envisioned in resilience literature because they fulfil several core criteria. They are explicitly experimental, and are aimed at gathering hard evidence rather than achieving specific targets, meaning the core objective is knowledge acquisition. They acknowledge the importance of a holistic approach that emphasises working with natural processes. Finally, they are partnership projects where measures are not dictated centrally, but are produced through a collaborative effort between relevant stakeholders, which should theoretically lead to more diverse sources of knowledge that help support decisions.

Among a multitude of proposals submitted by various interested partners, the three chosen project sites and partners were:

- "Making Space for Water Project" (Dark Peak, Derbyshire) - Moors for the Future/Environment Agency
- "Source to Sea Project" (Holnicote, Somerset) - National Trust
- "Slowing the Flow Project" (Pickering, North Yorkshire) - Forest Research/Forestry Commission

Only the Holnicote and Pickering projects will be used as case studies in this chapter because the Dark Peak project was implemented at a much smaller scale than the other two, with fewer measures implemented and fewer stakeholders involved (Pilkington et al., 2013). This meant that potential learning from the Dark Peak project would have been more limited than for the other two projects.

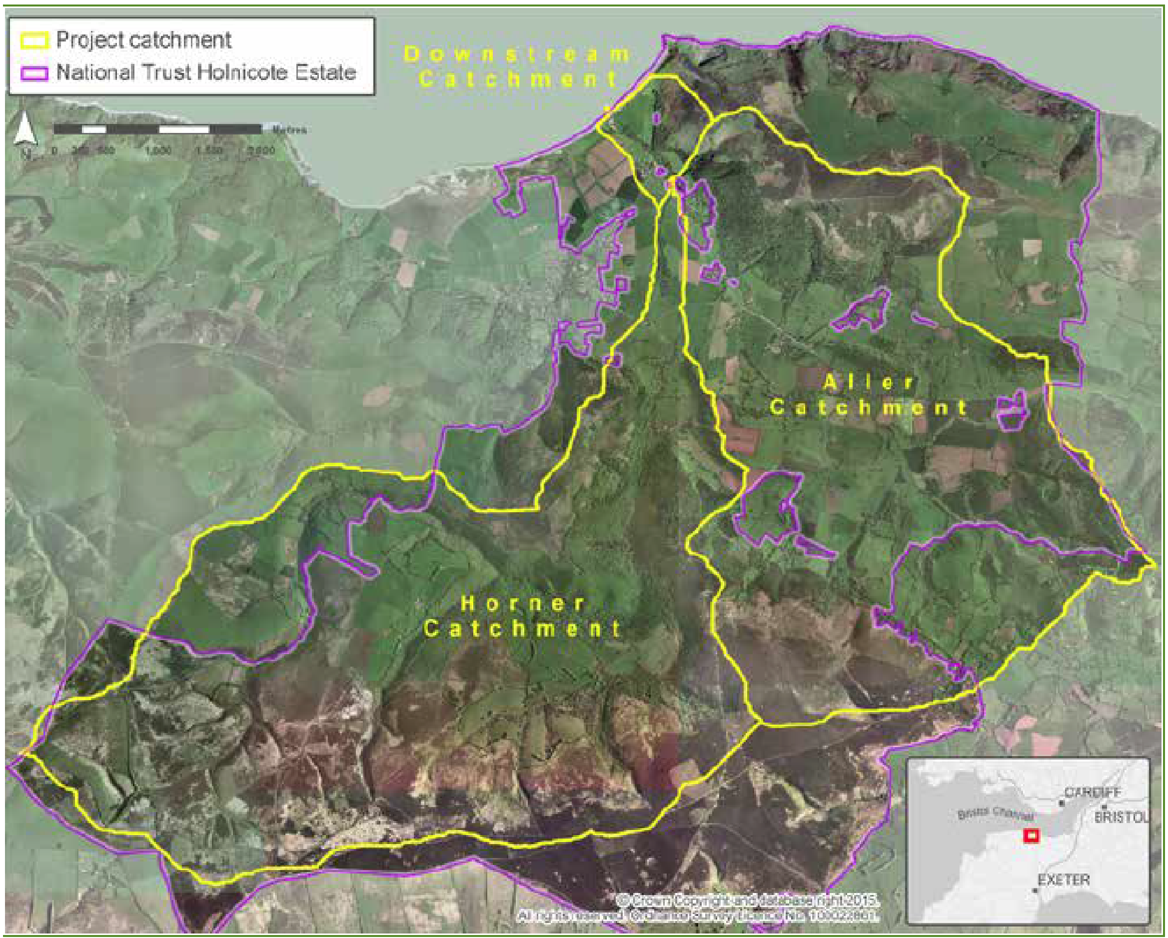
3.3.1 Holnicote

The "Source to Sea Project" comprises two study catchments, Horner Water and the Aller, which are situated wholly within the Holnicote Estate owned by the National Trust (see Figure 3.1). Project implementation at Holnicote took place between 2009 to 2015, with an initial phase in 2009-11 constituting mostly modelling and scoping work to identify appropriate sites to implement measures. The measures were implemented mainly in 2012-13 and include: moorland drainage impedance, woody debris dams, woodland creation, leaky weirs and offline flood storage areas. Almost all of the tenants living on the Holnicote Estate reside in the downstream Aller catchment area, whereas most of the more intrusive initiatives, such as woodland creation and woody debris dams, were implemented in the upstream Horner Water catchment area. Since the project area is on the edge of Exmoor National Park, and waterways flow directly down to the sea, relevant stakeholders are limited to the Environment Agency (EA), the National Trust (NT), village residents in Allerford, West Lynch, and Bossington, as well as tenant farmers.

3.3.2 Pickering

The "Slowing the Flow Project" includes the River Seven and Pickering Beck catchment areas, which include the towns of Sinnington, Wrelton, and Pickering (see Figure 3.3). The project took place between 2009 to 2015, with phase I taking place between 2009 - 2010, and phase II from 2011 - 2015. The initial phase comprised mostly of modelling and scoping

Fig. 3.1 Holnicote Project Area

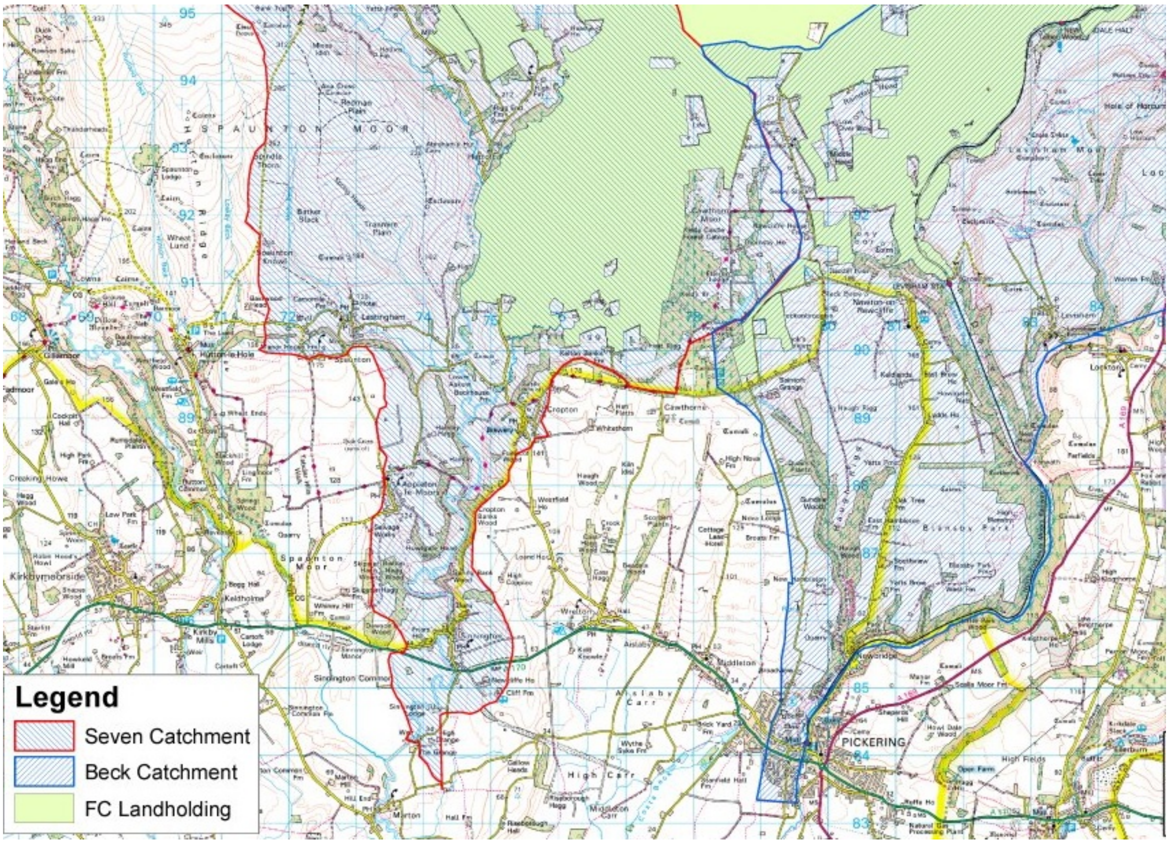


Source: NT (2015)

Fig. 3.2 Flood Bund

Source: Landscape Institute

Fig. 3.3 Pickering Project Area



Source: Forestry Commission

work, with limited work on planting woodland, building large woody debris (LWD) dams, and blocking moorland drains. Much of the work in phase II was delayed due to funding shortages, but the remaining work, including planting woodland and building a low-level bund near Newbridge, roughly one mile upriver from the town of Pickering, was completed in early 2015. A bund (Figure 3.2) in this case refers to a type of water retention area, much like a reservoir, which allows water to flow through unimpeded under normal conditions, but backs up at times of flooding, forcing the water to run into surrounding fields. Relevant stakeholders either involved in or affected by the project include: Forest Research/Forestry Commission (FC), the EA, North York Moors National Park Authority (NYMNPA), Ryedale District Council (RDC), Pickering Town Council, local residents, and farmers.

3.4 Method for case studies

The issues of scale and finding suitable definitions for what is meant by "local" (or "community") affect both the structure, and the findings of the study. The definition of "local" used in this study is largely guided by the way in which FRM is structured in the UK, where the lowest level of "granularity" is essentially at the county district level. Therefore, the local population – or community – is defined as residents who live within Ryedale district. This is obviously an imperfect definition since a single flood event can cross over multiple districts for example. However, it has been chosen because of it being the lowest level of granularity for policy implementation, and thus the most immediate level at which residents and local populations can engage with policy makers and practitioners.

The aim of the case studies is to determine if a recursive learning process as envisioned in resilience literature is feasible in a practical policy context. To do this, it is imperative that *learning* is clearly defined, so that a set of structured questions can be devised to guide the analysis that can help determine its practical feasibility. However, as has already been mentioned, *learning* is conceptualised in multiple ways in resilience literature, and there is no little coherence in the theoretical framework that can guide the formulation of relevant questions. To account for this issue, I have borrowed a theoretical framework of *learning* used in policy change literature in order to identify a set of descriptive properties for learning, that I use to guide the line of enquiry. Using this set of properties (adapted to reflect *learning* as conceptualised in resilience literature), I examine experimental FRM projects that have been implemented in practice to determine whether a resilience approach to learning is feasible for practical policy implementation. The core questions used to triangulate a suitable definition for *learning* are mainly based on Bennett and Howlett (1992), and Grin and Loeber (2007)'s set of questions for identifying various types of learning:

1. What are the subjects of learning (who learns)?
2. What are the objects of learning (what do they learn)?
3. What is learning supposed to contribute to (what is the objective)?
4. How does learning come about (drivers of learning)?
5. What constitutes learning (when has learning been achieved)?

Properties of learning in resilience literature

By interpreting conceptual descriptions found in resilience literature, the descriptive properties that define *learning* are:

Table 3.1 Learning in resilience literature

Who learns	Everyone involved, including practitioners, stakeholders, and institutions
What is learnt	New knowledge useful for improving policy instruments
Objective of learning	Knowledge acquisition that leads to policy change and adaptation
Drivers of learning	Changing external conditions such as increasing frequency/magnitude of natural disasters
What constitutes learning	"True" learning is achieved when there is adaptation - meaning the "policy paradigm" of how soceity understands a problem - shifts

In resilience literature, learning by individual practitioners is frequently analogous to organisational learning (Boyd, 2012). This is a strong assumption since it entails that whatever new knowledge gained by individuals will be distributed to, and accepted by their colleagues, and the organisations they work for. It is unclear to what extent new knowledge gained by individuals is assimilated by others. In fact, Etheredge and Short (1983) identified that learning can be done on the level of the individual, of a team, and of the collective whole. Knowledge transfer between these different levels of stakeholders is not well understood (Leeuw et al., 2000), and drawing an analogy between individual and organisational learning is highly assumptive.

The questions of "what is learnt" and the objectives of learning are intertwined with adaptation and the recursive process in resilience literature. This means the objective is for society to adapt, and policy learning implies identifying the correct instruments and practices that enable adaptation. As mentioned previously in section 3.1, this assumes that only new relevant knowledge acquired during the implementation leads to changes in policy, and that there is consensus on the necessity of these changes by all relevant stakeholders. These assumptions are in contrast to current research into policy learning, where it is generally agreed that policy programmes do not exist in isolation from the overall policy system, and securing agreement between stakeholders is far from straightforward (Reber, 2007; Yamori, 2011).

Experimental - recursive - learning suggests that true adaptation to flooding necessitates repeatedly exposing an area to flooding, thereby permitting continuous data monitoring and minor improvements on policy design. Learning, in the form of incremental improvements, will contribute to better flood management practices and a more resilient/adaptive society. Needless to say, communities at risk of flooding are highly unlikely to approve of measures that require their homes to be periodically flooded, even if they are told that this might improve their capacity to deal with flooding in the long run. Reactive learning and policy change may indeed be feasible for dealing with most natural disasters, but it is also likely to be impracticable in the field of FRM.

The emphasis in resilience literature on shifting the "policy paradigm" is highly ambitious, since it is a very profound measure of learning that requires stakeholders to change their "core beliefs" (Sabatier, 1999) of a problem. A way to understand the significance of this requirement is to use Hall (1993)'s classification system, which has three forms of learning, each one being more difficult to attain than the previous:

- First order learning – the most basic level where learning only affects specific settings of basic policy instruments, for example adjusting the strength of levees and dams or dredging rivers
- Second order learning – a more profound level of learning where the policy instruments themselves change, for example switching to upstream water retention measures in addition to (or in place of) dams and levees
- Third order learning – highest level of learning that leads to changes of the "policy paradigm", where rather than preventing flooding, the objective shifts to making societies capable of living with flooding

Learning that leads to adaptation and shifts in the "policy paradigm" clearly necessitates third order learning. However, there is currently little empirical evidence of deliberate policy interventions succeeding in altering the core beliefs of targeted stakeholder groups. It would therefore be relevant to question whether adaptation through recursive learning is a realistic proposition given real world constraints.

Questions for the case studies

Taking into consideration the concerns outlined above, the analysis of the learning process during the experimental project case studies will focus on answering the following questions:

1. Do actively involved stakeholders learn and gain new knowledge from project implementation?

2. Is policy change only motivated by newly acquired knowledge? (E.g. outside factors do not influence outcomes)

3. Do policies change as a result of knowledge gained from project interventions?

4. Is it feasible to have environmental conditions serve as the driving force behind policy changes?

5. Has the project succeeded in fostering a “paradigm shift” in FRM in the case study areas?

Data collection and sampling

Data for the case studies were taken from a combination of written reports and interviews with relevant stakeholders, conducted in-person as well as over the phone. The review of written reports is intended to provide a baseline understanding of the project specifications that could inform pertinent questions to ask during the interviews. This allows the interviews to focus on exploring the underlying motivations for various stakeholders, as well as contextual factors (politics, finances etc.) that may have influenced project implementation. The goal is to elicit better insight into whether these experimental projects could fulfil the criteria of recursive learning, which in turn would hopefully provide clues regarding the feasibility of the resilience approach.

The interviews were all conducted using a semi-structured (Bryman, 2004) format to allow certain core questions to be answered, while allowing room for more exploratory dialogue in order to gain insights that may not have previously been considered. They were all held after completion of the pilot projects, in late 2016 and early 2017. The process of selecting interview candidates was carried out using a snowball, or chain sampling, approach where I initially browsed readily available policy documents and general media coverage, identifying certain key individuals who were centrally involved in the projects. As I interviewed these key individuals, I also asked each one to refer other individuals whose input might be useful. The focus when selecting interview candidates was primarily on policy practitioners and managers from Defra and the EA who are directly engaged with policy implementation, either in a strategic or operational capacity. Some local stakeholders were also interviewed to provide insights from the viewpoint of those that are affected by the policies introduced in the pilot projects. A detailed list of relevant stakeholders that were interviewed for each project can be found in Appendix A.

Regarding the interpretation of the results from the interviews, it needs to be acknowledged that establishing a strong degree of certainty can be challenging in qualitative research, since reality is multi-dimensional and ever-changing, and finding objective phenomena (if such a thing exists) is extremely difficult. Focussing on practitioners and managers directly engaged with implementing policy obviously means that the results can only capture a segment of the overall picture. The interviews do not give a full account of the perspectives of other stakeholders such as local residents, academic researchers and other organisations that were involved with the project. As such, the findings from this chapter should not be interpreted as a complete representation of "reality". I attempted to validate the replies given by the interviewees from Defra and the EA by controlling that any information or opinion is expressed by at least two individuals (preferably more), which is a common sampling technique (Patton, 2005). This does not necessarily mean that the replies are wholly representative of the two organisations however, or that the personal opinions of the interviewees are completely filtered out. But it does at least remove replies that are wildly inaccurate. With these limitations in mind, the interviews can still offer some useful insights since Defra and the EA play such crucial roles in the FRM process. By identifying whether two core FRM stakeholders in the UK encounter difficulties learning and changing according to inputs and new knowledge gained the pilot projects, it may be possible to glean insights into the feasibility of learning through experimentation.

3.5 Results and analysis of case study interviews

A summary of the core information gathered from the interviews can be found in Table 3.2.

Table 3.2 Summary information from interviews

	Defra	Environment Agency	National Trust *Holnicote*	Forestry Commission	North York Moors N.P. *Pickering*	Ryedale D.C.
Motivation for project participation	Projects were useful scoping studies to determine efficacy of NFM intended to inform future strategic funding decisions	A way to discover new (more affordable) means of fulfilling statutory obligations given increasing budgetary pressures	Primarily driven by desire to explore new means to meet statutory obligation to conserve its land, wildlife, buildings and archaeological sites	Wanted to see if meeting its strategic objectives of planting more woodland could be further justified by potential FRM benefits	The Pickering Beck area is directly downstream of water sources originating in the national park, so park authorities needed to be involved	Other proposed initiatives did not meet cost-benefit requirements so the pilot project was the only option available
New knowledge gained	- NFM works, but is no “magic bullet” so little motivation for massive change in FRM policies - Multi-objective role of NFM is promising, but Payment for Ecosystem Services (PES) potential is limited	- NFM works, but there are concerns whether it can “deliver the numbers” needed to be an alternative to standard FRM measures - NFM is a useful tool for meeting biodiversity and ecosystem protection goals	- Switch to “Land choices” approach for managing tenanted farmland for providing ecosystem services in addition to rental income - Set up “Catchments in Trust” partnership with EA to further explore PES possibilities of NFM	- Monitoring and modelling of woodland flood flow control is still ongoing so no definitive conclusions have been drawn - Past experiences play an important role in the perception of woodland planting among local communities	- NFM measures can be a useful way for the park to ensure water quality and biodiversity as required in the Water Framework Directive - Building of “leaky dams” is a promising way to introduce low profile FRM measures	- Flood storage bund can be an effective flood defence instrument - Little knowledge of other NFM measures like timber dams, woodland planting, farm run-off control - Tourism as means of securing partnership funding for FRM
Flood risk management policy change	Partial	Partial	Yes	Yes	Partial	Partial
Who learns	Individual, limited organisational learning	Individual, limited organisational learning	Organisational	Organisational	Organisational	Individual, limited organisational learning
View of flood exposure as learning tool	Negative	Negative	Negative	Negative	Negative	Negative
Evidence of paradigm shift	No	No	Partial	No	Partial	Partial

3.5.1 Holnicote

1. Do actively involved stakeholders learn and gain new knowledge from project implementation?

The interviews indicate that all three major stakeholders – Defra, the EA, and the NT – have gained new knowledge, although this is less certain for the NT since only one individual representing them was interviewed. While it appears that all three major stakeholders learned from the pilot project, they do not necessarily agree on how this new knowledge should be interpreted. For the NT, the key lesson learnt was that "Holnicote showed [the NT] what can be achieved with very little money by simply working with nature", and the insights gained during project implementation have been diffused throughout the organisation through the *Land Choices* programme. Knowledge acquisition at the EA and Defra on the other hand, have been more nuanced. Even though all the interviewees acknowledged that the findings from the project are promising, noting that "[Defra] sees NFM as an important part of [their] strategy to protect the country from flooding", both EA and Defra representatives were cautious about not over-interpreting the results. One interviewee noted that there is wide-spread appreciation within the EA that the project did have an impact on reducing peak flood flow during the 2013/14 winter floods, and that NFM can make "contributions to reducing flood risk". However, they were unsure whether these natural measures would be effective under all circumstances since "[the EA] only have rough estimates for how much the measures helped" reduce peak flood flow, because of the unpredictability of water flow and run-off. The sentiments expressed is that NFM "represents an extra element that can help slow down the flow of water to key locations", and is seen as complementary to conventional flood defences. The reason for the cautious approach is that there is some lingering doubt whether similar initiatives would be able to "deliver the numbers", in, for example, the number of properties protected, that traditional "big flood defences" can provide. One important issue stressed by both EA and Defra officials is that "it's just not possible to stop all flooding", and FRM is not simply a matter of choosing the most appropriate instrument, but is also determined by "how much money ministers are willing to spend".

2. Is policy change only motivated by newly acquired knowledge? (E.g. outside factors do not influence outcomes)

Information from Defra suggests that this might not be the case. When the Holnicote project was first conceived in 2009, Defra viewed it as an experiment for testing NFM measures, where they wanted to see whether it can "deliver more benefits than just reducing flood risk, such as improving water quality and preventing soil erosion". However, in 2011 the Government published a Natural Environment White Paper titled *The Natural Choice: securing the value of nature*. This led Defra to set up a research fund intended to support pilot schemes exploring the feasibility of Payments for Ecosystem Services (PES)[1], specifically how they can provide new sources of funding (Rogers et al., 2015). The Holnicote initiative was selected as one of the projects included in the third round of pilot studies (2014-2015) funded by the scheme. For Defra, using Holnicote as one of the pilot studies was primarily driven by a desire to explore how useful PES can be for making NFM projects "self-sustaining" by providing "its own source of funding". Thus, Defra came to view the Holnicote project not just as an experimental initiative exploring the viability of NFM measures, but also as a test-case for finding alternative sources of funding that can help support a variety of activities. The slight shift in focus on the part of Defra was motivated by the fact that "flood management is only one of [Defra's] responsibilities, and [Defra] saw an opportunity to explore if [PES] could free up resources for other areas". As such, Defra's engagement with the Holnicote project came to be defined as much by budget pressures and the search for alternative funding sources, as the original objective of testing the viability of NFM measures.

3. Do policies change as a result of knowledge gained from project interventions?

It is unclear to what extent FRM policies have been affected by the Holnicote project. This is in part because Pickering is by far the more widely recognised initiative of the three Multi-Objective Flood Management Demonstration Projects, and therefore any changes in national policies would most likely be attributed to the Pickering project. Also, as is evident from the responses by the interviewees to the first question, there is a desire not to prematurely change policies based on a limited sample of projects. The Holnicote project has however, seemingly led to policy changes at the NT, where it "inspired a deeper appreciation for the potential of ecosystem services", and is regarded as a key catalyst for the *Land Choices* programme. *Land Choices* is meant to change the way the NT manages its land by adopting an ecosystems approach in order to better balance its aspirations of landscape, wildlife, and architectural preservation. The "[NT] was interested in a wide range of benefits from the outset" of the project, and the hope is that PES can be a feasible means of generating income by "making public enjoyment a financially viable function" of land the NT manages. To this end, the NT has partnered with the Green Alliance to develop the

[1] Payments for ecosystem services (PES) are market-based mechanisms intended to foster greater natural resource conservation. They are incentives, usually in the form of conditional payments, offered to farmers or landowners in exchange for managing their land to provide some sort of ecological service that benefit communities.

concept of Natural Infrastructure Schemes in order to explore the market potential for land and nature that will be used to support its *Land Choices* initiatives (Rogers et al., 2015). Furthermore, in 2015 the NT and the EA formed the *Catchments in Trust* strategic partnership for developing catchment scale projects within NT land across England to further explore synergistic opportunities between NFM and conservation goals (NT, 2015).

One interesting issue that came up during the interviews is how organisational structure can affect learning. One interviewee mentioned that a potential issue that might have affected the efficacy of the NRM initiatives implemented at Holnicote are river maintenance activities above the Horner and Aller Catchment areas (where the pilot project was implemented).

> *"At one point during the project, we found out that some contractors were undertaking river dredging activities in the areas upriver of the pilot project sites. This could have undermined our efforts since it could have resulted in greater flows downstream before the project initiatives had been put in place... It turned out that they had been contracted by our local Operations team in the [Wessex region][2] to carry out dredging on [the EA's] behalf. Those of us involved in [the pilot project] are part of the FCRM Allocation and Asset Management team, so we were not aware of this until it was almost too late."*

The above quote suggests that the distinction between individual learning and organisational learning may be highly pertinent. The lack of co-ordination and communications hints at a siloed structure at the EA that raises the question of whether learning done by an individual, or even a group, necessarily leads to overall policy change. In the case of Holnicote for example, it is unclear whether the learning done by the FCRM team is mirrored by the Operations team, and it is therefore unclear to what extent the EA – as an organisation – has learnt from the pilot project.

4. Is it feasible to have environmental conditions serve as the driving force behind policy changes?

None of the stakeholders interviewed see exposure to flooding as a feasible option of gaining new knowledge to inform future policy choices. Interviewees at EA and Defra were primarily concerned about the legal implications of such an approach and pointed out that, even if it would be useful for gaining new knowledge, "[they] could probably not legally

[2]The EA underwent some organisational changes in April 2014, and as a result its regional offices changed names. At the time of the pilot project, the Wessex region was referred to as the South West region

conduct such an experiment" since they have statutory obligations under the Flood and Water Management Act 2010 to prevent flooding and reduce flood risk. It was mentioned that to implement an experimental initiative that allows areas to be flooded would require "a lot of Government Acts to be temporarily suspended", which they did not see as practicable. Also, they pointed out that "it's not even certain that these experiments would give conclusive results", which makes it extremely difficult to get any kind of support from "regular people" and affected communities. One interviewee at the EA also mentioned that it would be "politically disastrous" for a minister to approve such an approach, and they would almost certainly not be allowed to carry out such policies even if they thought there were potentially beneficial outcomes. The NT's objections meanwhile are more financially motivated. The Trust is responsible for property insurance on their estates, and a policy of deliberately exposing them to floods would have "dire consequences on [their] insurance costs". Also, the Holnicote estate is reliant on tourism as a significant source of income. Repeated flooding on the estate would be "unnecessarily self-destructive" since it would likely diminish visitor numbers, making them unable to fund other works they are obligated to carry out.

5. Has the project succeeded in fostering a paradigm shift in FRM?

Of the institutions involved, the strongest case for a policy paradigm shift appears to be at the NT. The initial positive results from the Holnicote project in limiting flooding during the 2013/14 Winter floods have been a key driver behind the organisation's shift towards emphasising catchment-wide initiatives and more diverse land management practices, as proven by the new *Land Choices* and the *Catchments in Trust* partnership programmes. However, it could be argued that these changes are more in line with Hall (1993)'s concept of Second Order Learning rather than a true paradigm shift (i.e. Third Order Learning). While the NT has indeed started emphasising the importance of NFM, this does not necessarily deviate much from their overall organisational objectives since the NT has always had a statutory obligation for landscape conservation. Thus, the true shift can be found in the NT's strategic approach towards funding its initiatives. For example, tenanted farmland has traditionally been viewed as productive land that provides rental income that is used to support the NT's wider works (NT, 2015). The Holnicote project "inspired a partial rethink [within the NT] of how land is managed", and they are currently exploring whether providing "public enjoyment" by expanding the water, wildlife, and landscape functions of the land, can be as viable as productive farmland through for example PES schemes.

While the interviewees from both the EA and Defra found the results of the Holnicote pilot project to be promising, they still expressed some lingering skepticism regarding the viability of NFM. The two primary concerns expressed during the interviews were the capability of NFM measures to “deliver the numbers”, and the issue of how they can be “scaled up” for larger geographic areas. The EA mainly seems to see its task as “using whatever resources [they] have to provide as much flood protection as possible”, and while the interviewees expressed optimism about the cost-effectiveness of NFM measures, they do not see the project outcomes precipitating wider changes to FRM policies since there is still too much “that [they] don’t know about the effectiveness of natural measures”. The Defra interviewees meanwhile, were cautious about how pilot initiatives such as the one at Holnicote can be scaled up to larger geographic areas. Since NFM relies on the interaction between various natural processes (varying soil retention levels, water flowing through woodland, wetlands etc.), the “level of planning and co-ordination required” to work across larger geographic scales is “incredibly difficult” to achieve. This requires co-operation between Government Departments (since transport, energy, and other sectors might be affected) as well as local governments and other interested parties. They did not see a straightforward way to make all the pieces fit together since “too many people are involved to make it a realistic option” in comparison to traditional flood defences.

3.5.2 Pickering

1. Do actively involved stakeholders learn and gain new knowledge from project implementation?

Most interviewees in the case study represent either Defra or the EA, with three representatives from the RDC, and one representative from the NYMNPA, the FC, and a local community group respectively. As such, insights from the interviews will largely be focussed on learning from the perspective of Defra, the EA, and the RDC. Like the findings from Holnicote, the stakeholders have interpreted the project results differently, which could partly be attributable to differences in their problem definition and motivation for participating in the project. Since Pickering, like Holnicote, is one of three pilot projects funded under the Multi-Objective Flood Management Demonstration Projects scheme, the knowledge gained and lessons learnt by the EA and Defra are very similar for both projects. Interviewees from both major stakeholders view the project outcomes as promising, noting that the measures “made an effective contribution to reducing flood risk”, and see NFM measures similar to those introduced in Pickering as possible future alternatives to be introduced in “low priority areas” where more traditional flood defences are not cost-effective. Interviewees at Defra also expressed optimism towards the multi-objective elements of the project in that NFM measures are viewed as "an effective way for [Defra] to meet multiple organisational objectives" (such as habitat protection, water quality, ecosystem conservation etc.), which is not as easily achieved with traditional flood defences. Their view is that as long as NFM measures can provide "acceptable reductions in flood flow" that leads to lower flood risks, then the ability to target multiple objectives would be of great value under specific circumstances.

Representatives from Ryedale District Council (RDC) were particularly pleased with the project outcomes since the building of low-level bunds at Newbridge seemed to prove effective in preventing flooding during the 2015/16 winter floods by reducing "peak flood flow by up to 20%". The RDC had originally vociferously supported more traditional flood defence measures around Pickering since the town has a history of flooding (most recently in 1999, 2000, 2002 and 2007) (Nisbet et al., 2015). When a cost-benefit analysis carried out by the EA indicated that solid flood defences would be too costly, the "[RDC] had to grudgingly accept that the [pilot project] was the only option left if [they] wanted any action to be taken at all". To have their "second choice" option achieve comparable results to costlier alternatives was the deciding factor in accepting NFM as a viable option, and as one interviewee put it: "[the project] has given evidence that there are alternative cost-effective methods of protecting the area from flooding, other than just concrete walls". However, the RDC had three environmental managers in charge of co-ordinating with the pilot project since its conception. During the interviews it was made evident that the turnover has had an impact on knowledge transfer within the local authority. While the manager involved at the planning stages of the project was familiar with all aspects of it, currently the RDC seems to view the building of the Newbridge bund as the primary outcome of the pilot project. While aware of the woodland planting, and building of wood debris dams, they do not associate it with the objectives of the Pickering pilot project.

The two interviewees representing the NYMNPA and FC expressed that both organisations had similar goals for the project, which included water quality improvements, reducing sediment loading, and improving ecological status and habitats (Nisbet et al., 2011). While the NYMNPA have been largely happy with the outcomes, the FC was unable to meet its woodland planting targets due to significant objections from local communities, many of whom were "upset and strongly protested against any changes to the 'iconic"' moors landscape. This has meant that it will be much more difficult to determine the efficacy of woodlands as water retention mechanisms since the most sensitive parts of the project catchment were discounted. Interestingly, the interviewee from the FC mentioned that one of the main lessons from project implementation was not of a technical nature, but rather how influential past experiences can be for how the local community perceived the project. Historical woodland planting in the National Park area (post-war through 1970s) had largely been aimed at timber production, and most of the trees were not native species, which had negative consequences for wildlife and landscape preservation efforts. One interviewee from the FC speculated that "the ill-conceived efforts from the 1970s probably gave woodland planting a bad connotation" for the local population in Pickering, and these experiences have left them largely skeptical of the merits of such measures, which impeded the FC's efforts for the Pickering project despite modern woodland planting initiatives having "a much deeper understanding of the need to balance various needs".

2. Is policy change only motivated by newly acquired knowledge? (E.g. outside factors do not influence outcomes)

Interviewees from the EA and FC were in agreement that one of the most difficult challenges of the project was ensuring that local stakeholders remained interested and engaged in the implementation. The delay of building the low-level bund at Newbridge to 2014 posed a significant threat to the continuation of the project, because the RDC had pledged a considerable amount of funding for its construction. Ensuring that this local financing – which was essential for building the bund – remained available, became the most important task for the project co-ordinators. One interviewee explained that:

> *"because the [Newbridge] bund is so big, construction couldn't begin until we obtained planning permission under the Reservoirs Act 1975 to ensure that people's lives would not be put at risk if the bund failed... this process usually takes a long time and [meanwhile] a number of people in the local council felt that the £950,000 they had pledged during phase I of the project would be better spent elsewhere rather than just being kept aside... without the local financing then the bund probably wouldn't have been built, so I spent a considerable amount of time simply making sure that the local funding would still be available once [the bund] plans were approved"*

Applications for permission to build the bund were submitted early 2011. At that point, the total cost was expected to be £1.15m, with Ryedale contributing £950,000, the Yorkshire Regional Flood and Coastal Committee (RFCC) providing £150,000, and the EA adding £50,000 (Nisbet et al., 2011). By the time construction of the bund finally started in January 2014, the estimated cost had risen to £3.2m. While project co-ordinators had succeeded in ensuring that the funding from local authorities remained available, the extra costs resulted in a steep shortfall of project financing. In the end, the missing funding was secured through a combination of grant-in-aid[3] provided by Defra and EA, as well as partnership funding made available to the North Yorkshire County Council. Essentially, even if flooding is an important issue in the area, there are also other matters that require the attention of the RDC. If the funds had been spent elsewhere, then it is unlikely that the project would have proceeded. In this case, its discontinuation would not have resulted from any new knowledge or information gained through project implementation.

Interestingly, it became evident through interviews with Defra and EA officials that a key individual involved in securing the additional funding for the bund was Baroness Macintosh, then Chair of the House of Commons Environment, Food and Rural Affairs Select Committee. She, in her capacity as the MP for Thirsk and Malton (the parliamentary constituency of which Pickering is part of), had taken personal interest in ensuring that the Newbridge bund was built. She had in fact been “highly vocal in her demands for the Pickering area to have suitable flood defences after the latest flooding in 2007”, and was initially “not entirely smitten” with the unfavourable outcome of the EA’s cost-benefit analysis. She became more favourable to the project however, when told that “modelling suggested the bund would reduce the risk of flooding in Pickering from 25% to 4%” in any one year. The interviewees at the EA and Defra were in agreement that without the influence exerted by Baroness Macintosh in securing “extra funding from the Government to supplement the additional funds that the [North Yorkshire] County Council had pledged”, the completion of the project would have been in doubt. In this case, the political influence of one individual seemingly played a crucial role in achieving project objectives.

3. Do policies change as a result of knowledge gained from project interventions?

There is some evidence that the Pickering project has had greater success in influencing policies than the Holnicote project. The interviewee from the FC suggested that the project has “had an impact on how [it] shape[s] [its] water management initiatives” under the English Woodland Grant Scheme, and the Countryside Stewardship Scheme. It has also been used as inspiration for experimental NFM elements of the Derwent Catchment Strategic Plan and the Cumbria Floods Partnership. Furthermore, in Defra’s Funding for Flood and Coastal Erosion Risk Management report for 2016/2017, Pickering is mentioned as an example of

[3]Grant-in-Aid is funding that Defra provides to the EA for funding high priority investments. The EA is able to pass on some grants to Local Authorities dependent on the public benefit that specific projects can provide. The specific funding structure is outlined in Figure 3.4

catchment-wide measures. Also, the Government has taken to using the expression "slowing the flow" (the project title used for Pickering) as synonymous with NFM (EFRA, 2016). When asked why the Pickering project has had more far-reaching impact on policies than the other Demonstration Projects in Holnicote and Derbyshire, despite positive outcomes at all three locations, the common response given was the influence of media coverage. The Pickering project has received significant attention in national media discourse, where both The Guardian and Independent newspapers have featured articles about the project. Sky News and BBC TV News also featured it in their programming, and BBC 1's Bang Goes the Theory ran a full episode programme about the Pickering project as well. While it is clear that the positive results, including preventing Pickering from flooding during the 2015/16 floods, are the reason why the project has received so much media attention, its disproportionate policy impact in comparison with the other two Demonstration Projects does raise interesting questions about how much of the influence is actually attributable to the knowledge gained through project implementation.

4. Is it feasible to have environmental conditions serve as the driving force behind policy changes?

Similar to the opinions expressed by the interviewees for the Holnicote project, no interviewee thought that reactive adaptation through exposure to flooding is a realistic policy option. Aside from the same legal and political concerns mentioned before, representatives from the RDC also pointed out that such initiatives would simply be too costly. Changing the appearance/landscape of the town is not an option since the local economy is highly dependent on tourism, and therefore the overall aesthetic of the area is highly important. Similar to the Holnicote Estate, there was fear that repeated flooding would likely diminish visitor numbers, which would have economic consequences for the local area. These sentiments can best be summarised by the following quote from one interviewee:

> *"if by 'accommodate for flooding' you mean changing the infrastructure and how the town looks, then I don't think that is good policy. I don't see how we could get residents to agree to it... even if we could get residents to agree, it would probably be bad for the local economy. Visitors to the North York Moors National Park are one of the town's main sources of income, and they stay here because they like the rustic, market-town feel. I don't think it would be worth it to risk losing visitors by changing things"*

Lastly, the interviewee from the FC mentioned that NFM measures might be different in that the focus is on water retention and slowing down water flow, rather than "funneling water away" like in traditional flood defences, "the goal is still to prevent properties from being flooded". Hence, deliberately allowing flooding to happen would be "incoherent with the purpose of using pilot projects to examine the effectiveness of natural measures".

5. Has the project succeeded in fostering a paradigm shift in FRM?

As mentioned briefly above, the RDC seems to have indeed become more favourable to "soft" FRM measures following the perceived effectiveness of the Newbridge bund during the 2015/16 Winter floods.

But at least in Ryedale, the sentiment expressed during the interviews is that the greater responsibility in FRM assumed by local authorities starting in 2011 was also critical to a change in mindset. One interviewee from the RDC indicated that:

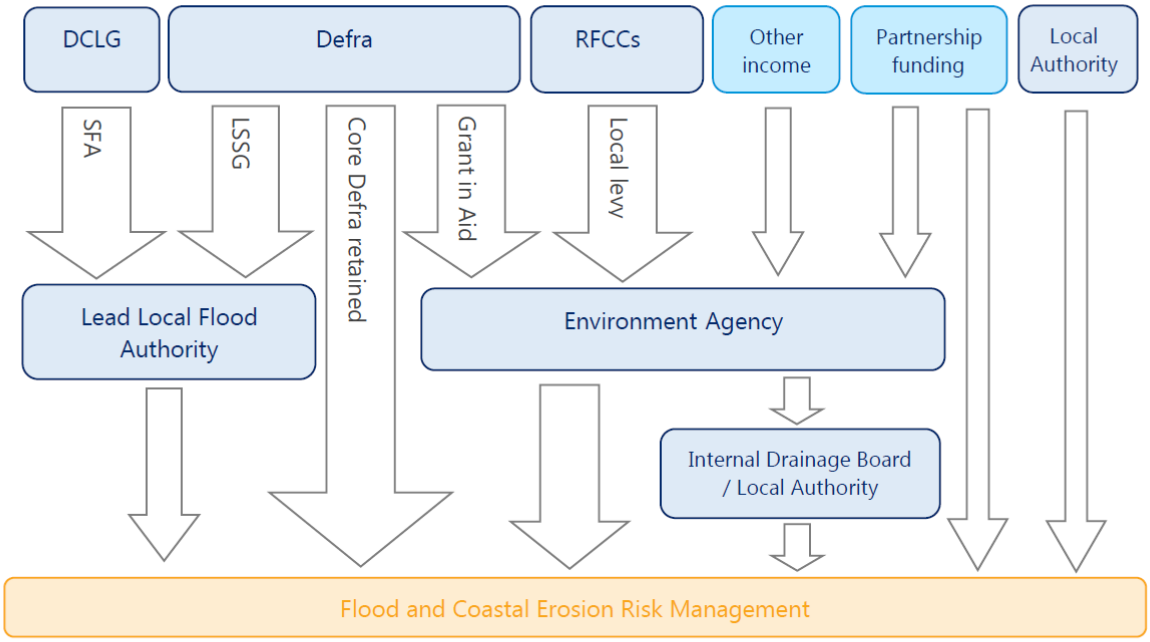
> *"we already knew from the failed cost-benefit analysis that the EA did in 2007 that there was little chance the Government would pay for flood defences for the town, and the changes in 2011 made it even less likely. Our thinking for phase II [of the Pickering pilot project] was that we had been given more responsibility, but not more money, so going ahead [with the project] became necessary because we would be left with nothing otherwise. With the new Partnership Funding[4] structure, measures like the [Newbridge] bund would be the only affordable thing available"*

Since the English flood funding structure changed in 2011 as a result of the Flood and Water Management Act 2010 and the Localism Act 2011, the need for bespoke local flood management arrangements have increased. The new funding structure (see Figure 3.4) meant that the only reliable source of funding for Ryedale became the Settlement Funding Assessment (SFA) and Local Service Support Grant (LSSG) paid to North Yorkshire County Council (NYCC) as Lead Local Flood Authority (LLFA), which would need to be shared with other districts within NYCC, or via the Partnership Funding scheme. More specifically, under the current funding structure, it is in Ryedale's (and North Yorkshire's) interest to focus their efforts on securing less expensive NFM measures, since the area's low population density means that it is a low priority area, and would not be eligible for more expensive

[4]The Flood and Coastal Resilience Partnership Funding scheme allows FRM projects to claim limited funding from the Government, but mainly expects funding to come from external sources such as local councils and businesses. The idea behind this scheme is to encourage communities to take ownership, and manage their own defences, which is said to help increase local involvement

flood defence measures.

Fig. 3.4 FRM funding structure in England.



Source: CIWEM (2015)

Furthermore, the increased FRM responsibilities for local authorities can entail significant difficulties for them, since they do not necessarily hold the required technical expertise that EA staff have. The issue of relevant technical knowledge is summarised by one of the RDC managers interviewed:

> *"Flood management is only one of my responsibilities. I also have to handle other matters such as waste disposal, food safety, air quality and so on. Flooding is obviously important for the area, but I'm no expert on [the topic]."*

Essentially, while it is true that the RDC views NFM much more favourably following the Pickering pilot project, they do not necessarily view it as a direct replacement for traditional flood defences. They are also unlikely to be in a position to have opted for alternative solutions, since the changing FRM structure in England means that such initiatives would require significantly more local funding and technical capacity than at least the RDC currently possesses.

It is unclear whether a paradigm shift has taken place within the FC, partly because most of the woodland planting initiatives were not carried out, and the project provided little conclusive evidence about the effectiveness of such measures. Also, because only one individual from the FC was interviewed, it is not possible to gauge the extent to which the entire organisation has learned from the pilot project. The interviewee did however, express optimism about the potential of LWD dams for flood management purposes, and indicated that similar initiatives would be implemented elsewhere, particularly in the Derwent Catchment area.

Finally, the EA and Defra expressed largely similar sentiments as for the Holnicote project. The interviewees do not see the pilot projects as harkening any paradigm shifts in FRM practices. In fact, based on the replies from the interviews, it would appear that the projects were seen more as means of testing unproven methods, rather than exploring entirely new ways of conducting FRM. For example, one interviewee from the EA involved with implementing the Pickering project stated that:

> *"we approached the project with quite clear ideas of what tangible results we wanted, which was to find out if [NFM] can be successful at preventing flooding. It was about seeing if we could add to our management toolkit rather than changing the way we conduct our work"*

Concerning the issue of scale, some interviewees from the EA mentioned the ongoing Derwent Catchment plans and Cumbria Floods Partnership as wider projects that can test the effectiveness of NFM measures. They believe that successful implementation in these larger projects would be a significant step towards alleviating some of the concerns about the viability of NFM measures. However, they were also cautious about what results could be deduced from these larger scale initiatives because it's unclear "how modelling all the processes can be done in practice", and whether it would be possible to "isolate the effects of the measures" from other natural processes at larger scales.

3.5.3 Other findings

There is general agreement among the interviewees that NFM can be effective for reducing flood risks. Following an analysis conducted by the Environment Agency after the 2015/16 floods, those involved in project implementation at Pickering concluded that "some flooding was avoided", and the measures appeared to be "working as expected, and reduced peak flood flow by up to 20%". There is however disagreement as to the extent of their effectiveness, with specific concerns regarding their capacity to "deliver the numbers" and efficacy across larger geographical scales. Regarding the Pickering project for example, all interviewees from

Defra and the EA generally agreed that the “measures installed have their limits” and would be insufficient to “prevent flooding of a similar scale as 2007”. One interesting observation pertaining to the issue of scale is that some interviewees, particularly from Defra and the EA, consider land ownership to be equally important as the need to collect more detailed scientific data on NFM. In fact, one interviewee from Defra acknowledged that: “the straightforward ownership situation was a determining factor” for the approval of Holnicote and Pickering as pilot project locations under the Multi-Objective Flood Management Demonstration Project programme. The entire Holnicote Estate in which project works were carried out are under the single ownership of the National Trust for example. While the land upstream of Pickering Town has three primary landowners, the FC, the NYMNPA, and the Duchy of Lancaster Estates. The interviewees from Defra and the EA expressed some skepticism regarding whether similar NFM initiatives would be possible in areas with a more fragmented land ownership structure.

One instance from the Pickering case study that seems to point toward the influence that land ownership can have on the practicability of NFM measures, is how local farmers and land owners responded to the initiative. Overall, there is consensus among the interviewees that the local community has generally been pleased with the project outcomes and have adopted a more favourable attitude towards NFM measures. However, there appears to be some discrepancy between how town residents and land owners have reacted to the pilot project, which might be due to financial reasons. For town residents, implementing NFM initiatives incurs no extra costs, and they need only consider whether measures are effective at flood management or not. For land owners and farmers on the other hand, initiatives such as woodland planting or farm-scale improvement measures could incur a loss of income. An example of their reluctance is that, of the six floodplain land owners that were canvassed for their willingness to plant woodland, only two expressed interest, neither of whom ended up agreeing to the arrangement. One interviewee mentioned that the two land owners who initially expressed interest, but later declined to proceed, most likely did so because “they lost all incentive to participate” in the project when possible compensation for loss of income was reduced from £4598/ha to £2299/ha (NWRM, 2013) as a result of the closure of the Regional Development Agency (Yorkshire Forward). Additionally, only 12 farmers signed up - and received grants - for farm-scale improvement measures proposed by the project. To illustrate the low uptake among local farmers, according to the latest figures from Defras Common Agricultural Payments (CAP) database, 287 farmers in the River Seven and Pickering Beck area (where the project is situated) received some payment for activities on their land. One interviewee from the EA, who was a member of the Programme Delivery Group, noted that they “made a number of farm visits and set up multiple workshops, but very few people showed up” to these sessions. Another interviewee from the EA mentioned that “some farmers thought initiatives should be done within the national park since it is upriver from their land, and effective measures there meant that [farm-scale] initiatives would not be needed”. The difficulty in engaging land owners is in line with experiences from similar initiatives, where resistance to these measures can be attributed to insufficient payments, loss of income, and perceived reductions in capital value of the land (Nisbet and Huw, 2008).

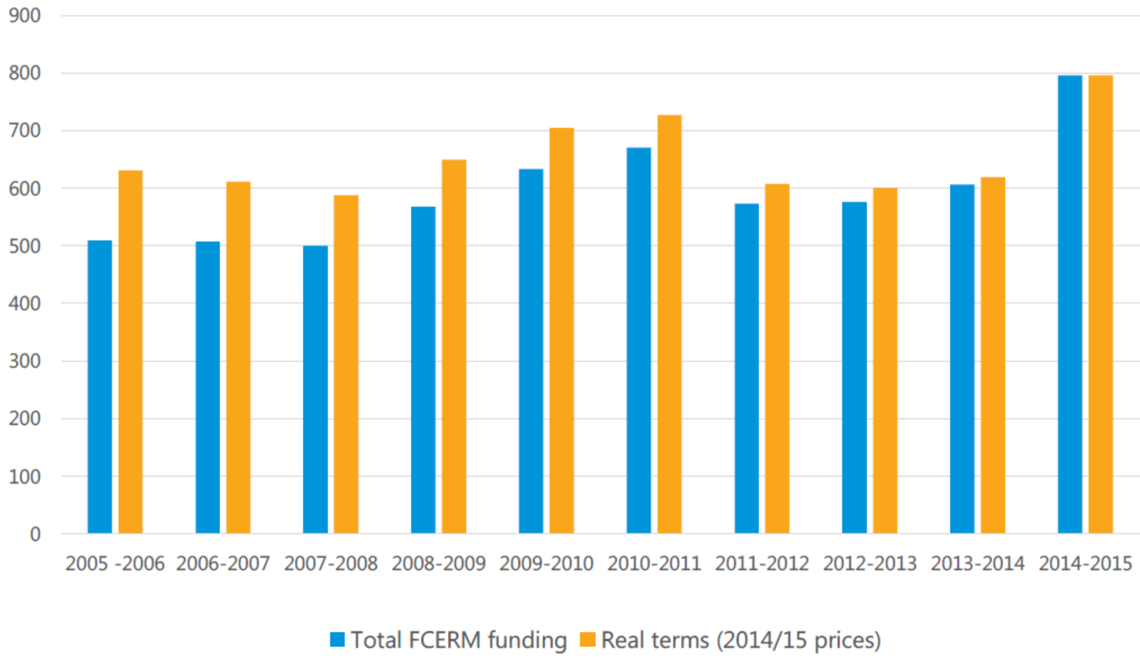
Resistance among farmers on the Holnicote estate was minimal compared with the experiences in Pickering (NT, 2015). The main contributing factor is likely that the Holnicote project has a locally-based project manager - Nigel Hester - who knows all 14 tenanted farmers on a personal basis, which led to good communication and involvement. With this in mind, it is also likely that the low number of individuals and the land ownership situtation also played a role. As the sole land owner, the National Trust is wholly in charge of insuring properties and maintaining necessary flood defences. Therefore, the tenanted farmers did not have to secure their own insurance, or pay for flood defence measures, which could have been an additional contributing factor to their favourable attitude towards the Holnicote pilot project.

Another issue that proved to be important to the pilot projects that receives little attention in resilience literature is the effect that forced-choice mechanisms (Lodge and Hood, 2002) have on policy choice. Empirical literature in policy learning have shown that public opinion, party politics, and media discourse can have an inordinate effect on policy choices (Bohensky and Leitch, 2014; Cairney, 2009). An example of forced-choice mechanisms at play is the 2013/14 winter flooding at the Somerset Levels, which interviewees from both the EA and Defra agreed was essentially a “media flood”, where the discourse centred around political considerations rather than any “real policy failures”. In the words of one interviewee:

> *“[the media] kept obsessing about dredging, but it wouldn’t have made any difference [in the Somerset levels]. The area is below sea level, and when there is heavy rainfall there is nowhere for the water to go. Dredging wouldn’t have helped”*

Indeed, despite receiving much of the national attention, the Somerset Levels comprised only roughly 150-200 of the more than 6000 total flooded properties during the 2013/14 winter floods (Purseglove, 2015). In response to the public outcry over the inundated areas, the Coalition Government, which had reduced FRM funding since it came to power in

Fig. 3.5 Total FCERM Funding 2005/06 to 2014/15 (£m)



Source: CIWEM (2015)

2010, promptly pledged an extra £200m in FRM funding (see Figure 3.5), including more than £20m set aside for river dredging, the favoured water management method amongst residents in the Somerset Levels (Webster et al., 2014). One interviewee observed that it is probably "not a coincidence that they miraculously found" extra funds that had hitherto been unavailable. The Somerset Levels experience lends credence to the theory that forced-choice mechanisms can indeed play a significant role as a driver for policy change by limiting the options available for policy-makers.

3.5.4 Synthesis and further remarks

Findings from studying both the Holnicote and Pickering pilot projects seem to support Sabatier (1999)'s theory that what is learnt during policy implementation is affected by what the stakeholders' original problem definition is. Experimentation and learning, as envisioned in resilience, might be possible, but stakeholders' learning can also be determined by their motivations for engaging in the first place. Organisational goals and objectives can be influential factors in how stakeholders perceive the problem definition of experimental policies, and also act as guideposts for what they actually learn. One issue identified in these case studies that is infrequently mentioned in resilience literature is the role that money plays in directing policy choices, and thereby affect policy change. The main source of lingering skepticism within the EA and Defra for example, are doubts of whether NFM initiatives are able to “deliver the numbers”, in terms of number of properties protected, that would justify significant investments. The interviews also suggest that the engagement from the EA and Defra was partly motivated by the desire to find cost-effective solutions of fulfilling their statutory obligations, and maintain acceptable levels of flood protection given increasing budget pressures. Evidence of acceptance of NFM measures by local stakeholders meanwhile, appears to be equivocal, with an influential factor being whether any financial costs are incurred. Interviewees from the RDC are content that their “second choice” option was effective in preventing flooding during the 2015/16 winter floods. Based on the interviewees’ accounts, it seems that local farmers and landowners are less supportive since many measures could potentially result in a loss of income for them. These differences hint at what Anbarci et al. (2005) have suggested is a major hurdle to policy change, namely that various groups cannot settle on what “all parties perceive to be an agreeable distribution of the burden of the necessary collective action”. Basically, the interviews suggest that policy change through experimentation is not necessarily a straightforward process, and involves significantly more political consideration than is acknowledged in existing conceptualisations of learning in resilience literature

Another key finding from the case studies is that knowledge acquisition is not necessarily the primary driver for policy change, even though it does seem to lead to stakeholder learning. Evidence from the interviews suggests that the overall policy context can be equally influential as the knowledge gained during the policy implementation process. For example, it is clear that all interviewees learned something from the “Slowing the Flow” project in Pickering. However, their motivation for accepting the use of NFM measures is also driven by external factors. The responses given in the interviews suggest that neither the EA nor RDC have changed their fundamental opinions that traditional flood defence measures would have provided the town with better flood protection. However, the changes in the national FRM and funding structure brought on by the Flood and Water Management Act 2010 and Localism Act 2011, and the increasing budget pressures put on the EA, led them to engage in a mutual sense-making of the new policy landscape. The favourable view of NFM is partly a reflection of these contextual changes that have affected both stakeholders, and the interviews suggest that they have adopted NFM principles as a suitable means of meeting policy objectives. This is not to suggest that the knowledge acquired through project implementation has not influenced policies, evidence from Holnicote and Pickering clearly indicate that they have. The issues of budget pressure and Localism simply serve to emphasise that policies do not exist in a vacuum, and the larger political environment as well as the greater policy context do play a role in the uptake of specific policy measures.

Additionally, findings from the interviews suggest that external factors, in particular forced-choice situations, can also exert considerable influence on policy change. An example of this is the "media-flood" in the Somerset Levels during the 2013/14 winter floods, where sustained media coverage seemingly led to the Government to reverse course on funding cuts to FRM (at least in the short-term). Another example of external factors driving policy change is the political influence exerted by certain individuals. One notable instance of individual political influence is that despite the positive results and lessons-learnt from phase 1 of the "Slowing the Flow" project, the extra funding needed in order to proceed with phase 2 (and the construction of the low-level bund at Newbridge) was secured in large part due to the involvement of the Baroness Macintosh. Basically, both the influences of political considerations, and outside factors (such as the media or new legislation) are likely to be more substantial determinants of policy change than is currently acknowledged by those who envision an experimental learning process for enhancing resilience.

Furthermore, an important matter that is left largely untreated in the resilience through experimental learning literature, is that in a policy context, knowledge acquisition and learning does not necessarily lead to knowledge transfer. One example that illustrates the problem of transferability, is the concern expressed by interviewees from the EA and Defra that NFM measures similar to those from the pilot projects may not be implementable at larger scales, or in locations with more fragmented land ownership structures. Given that the Government has pledged continued funding for NFM measures in England, it would be interesting to explore the extent to which initiatives like the ones in Holnicote and Pickering can be successfully transferred to different contexts. Empirical studies from other policy fields suggest that policy transfer can be very complex with equivocal results (Dolowitz, 2013; Oliver and Lodge, 2003). It would be interesting to see if the transfer of NFM measures can be successful transferred and exceed the expectations of the EA and Defra.

In conclusion, the findings from the case study interviews suggest that policy learning in a practical context bears little resemblance to the rational, experimental process envisioned in SES literature. While experimental projects can indeed lead to knowledge acquisition and stakeholder learning, evidence from the case studies suggest that their ability to impact and change policies is ambiguous. Importantly, the influence of outside factors, and the effect that the intents and motivations of various stakeholders, can be crucial factors that either drive (or prevent) policy change. It would therefore appear that a procedural process whereby policies change through recursive experimentation and knowledge acquisition is not a particularly feasible method, and thus offers equivocal added value for practical policy-making. Also, the finding about how motivations can determine what individual stakeholders learn from a project is particularly interesting, because resilience literature puts specific emphasis on the importance of collaborative and participatory methods for engendering collective "social learning" (Folke, 2006; Mees et al., 2016) that leads to more effective policies. If stakeholders do indeed learn selectively from a project, based largely on their original motivations for participating, then the ability to achieve collective "social learning" through participatory approaches may be questionable. The issue of what added value participatory methods can offer the policy process will be further explored in the following chapter.

Chapter 4

Participation and collaboration

4.1 Introduction

A corollary to learning through experimentation is the value that resilience literature puts into participatory methods. As mentioned in the introductory chapter, together, experimentation and participation form the procedural components of a resilience approach to policy-making. The thrust of the argument for greater participation is that it supposedly leads to better information-sharing and increased preparedness (Chang et al., 2014) by fostering "social learning". "Social learning" entails integrating diverse perspectives and promoting collective actions that will result in greater cohesion in local decision-making (Adger et al., 2012; Aldunce et al., 2014). It occurs when social memories and local knowledge are incorporated into institutional processes and policies that alter the community's ability to handle the next perturbation (Cutter et al., 2008), which theoretically mobilises all levels of knowledge in a society (Jabareen, 2013; Marshall et al., 2012). Essentially, the contributions of a participatory approach are greater diversity of problem perception (Becker et al., 2015; Jha et al., 2013), and allowing local communities to assume greater responsibility so that they do not become dependent on government interventions (Schultz et al., 2011; Weichselgartner and Kelman, 2015). These changes result in greater resilience by increasing the variety of potential solutions for dealing with uncertainty (Gaillard, 2010; Wardekker et al., 2010), and by inducing behavioural changes that lead to greater self-reliance (Lorenz, 2013; NRC, 2012).

Some scholars have pointed out however, that uncritically using local communities as a starting point for promoting participatory decision-making can result in deeply flawed outcomes, since it fails to take into consideration that there may be inherent contradictions and conflicts within them that can prevent beneficial outcomes (Cannon, 2008). One issue with uncritically engaging local stakeholders is potential "elite capture" (Dutta, 2009), which results in influential local individuals co-opting policy initiatives in a way that primarily benefits themselves rather than the local population as a whole. "Who is involved and how they are involved" (Aldunce et al., 2016) are crucial for determining whether participatory practices lead to better outcomes for local populations affected by disasters such as flooding. If delegating responsibility to local communities results in elite capture, then such an initiative would amount to little change, since the outcome is still that a majority of the local population have little say in what is decided.

Further complications arise from the fact that empirical studies of participatory methods as means of enhancing resilience have been mainly limited to micro-scale initiatives in developing countries, where communities have historically had minimal input in the decision-making process (Coulthard, 2011; Sikder et al., 2015; Wrathall, 2012). This is not the case in the UK for example, which has a long history of involving local stakeholders through public consultations and hearings, and other forms of participatory methods (Jordan and Maloney, 1997; Taylor, 2003). Important questions that remain unanswered include: (a) Are stakeholders able to freely engage in information sharing that leads to policy decisions, or are they constrained by existing political and policy contexts? And (b), does participatory methods necessarily lead to a greater range of problem perception, meaning, are the participants truly diverse and representative of the community?

This chapter will explore these questions by studying existing participatory bodies engaged in FRM in the area around Pickering, where the *Slowing the Flow* pilot project took place. Here, the "community" will be defined as local residents who could potentially be directly affected by the pilot project works in the Pickering area. Thus, "community" has a more geographical delineation than cultural, or socio-economic. The study will be divided into two sections, with one section focussing on the issue of potential political and contextual constraints. This will be done through a desk study of meetings documents obtained from existing participatory bodies in the Pickering area. A second section examines the diversity and representativeness of the local stakeholders that are likely to participate in these local bodies. This is done through a survey questionnaire sent to local residents around Pickering who are either directly involved, or have expressed an interest in FRM matters.

4.2 Participation, collaboration, and resilience

4.2.1 What is meant by "participation"?

The inclusion of participatory decision-making in the resilience field is not an isolated phenomenon. It is part of a recent broader revival of interest in stakeholder processes and engaging the public in government decisions (Brannan et al., 2006; Cornwall, 2008). The burgeoning zeitgeist of participatory approaches sees it as a means to strengthen the legitimacy and accountability of democratic institutions (Beetham et al., 2008), build social cohesion (Foot, 2009), foster reform of public services (Jochum et al., 2005), and boost self-confidence of citizens (Popay et al., 2007). Participation can be social, such as joining local association activities or volunteering in community organisations (Pattie et al., 2004); individual, by buying fair-trade products or voting (Ginsborg, 2005); or public, where communities engage with public institutions to affect policies (Jochum et al., 2005; Mohan, 2007). Within this wider context, resilience literature seems to fall within public participation, since it is implied that participation occurs between stakeholders and institutions (Folke, 2006). Ideally, participation is in the form of "multi-layered committees and multi-level collaborative platforms" (Boyd, 2012) that will empower local communities to influence policy decisions (Aldunce et al., 2014).

Basically, what seems to be described in resilience research is a process where stakeholders engage in an exchange of reason (Landwehr, 2010), where they communicate preferences, and through deliberation come to an agreement on suitable actions. Since they take into account the diverse knowledge and experiences of all stakeholders, these decisions are expected to be better informed and less self-interested (Hajer and Wagenaar, 2003; Huitema et al., 2007). Participation therefore arguably enables greater consensus-building by establishing links and networks between stakeholders that can help overcome initial disagreements and diverging interests (Reed, 2008). It is the preferred tool for dealing with cultural, economic and political "barriers" (Moser, 2008) that prevent societies from increasing their resilience.

Using the International Association for Public Participation's (IAPP) classification of various forms of participation (see Table 4.1), the format envisioned in resilience literature falls in the higher end of the spectrum where participation is collaborative or empowering.

Since the IAPP's classification systems is based on Sherry Arnstein's work on the "participation ladder" (Arnstein, 1969), the practical implication is that participatory bodies in resilience literature are afforded high levels of political mandate. While there may be

Table 4.1 IAPP classification of participation

	Increasing level of participation > > >				
	Inform	*Consult*	*Involve*	*Collaborate*	*Empower*
Public participation goal	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions	To obtain public feedback on analysis, alternatives and/or decisions	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution	To place final decision- making in the hands of the public
Example techniques	- Fact sheets - Websites - Open houses	- Public comment - Focus groups - Surveys - Public meetings	- Workshops - Deliberative polling	- Citizen advisory committees - Consensus-building - Participatory decision-making	- Citizen juries ballots - Delegated decision

intuitive appeal (i.e. more inclusive, relevance to local context) in granting stakeholders more direct power, doing so is not entirely unproblematic, as will be discussed in the next section.

4.2.2 Factors that complicate participation

Participatory bodies are not always inclusive and representative

In resilience research, the policy process is frequently conceptualised in binary terms, where decisions are either made through deliberations among stakeholders in a participatory forum, or made by policy experts in government ministries with little local input. In this conceptual framework, participation is depicted as a mostly positive process, where collective decisions act as drivers for beneficial social and structural change. But the reality is much more nuanced. Participatory processes can be exclusionary and divisive (Field, 2003), and they are equally likely to be formed to advance “nefarious as well as worthy ends” (Carothers, 2000). Participatory bodies are not always representative of local populations, and it is not always clear who is accountable for decisions made by these bodies (Bulkeley and Mol, 2003; Campos and Heilman, 2005). Stakeholders can also advocate reactive ideas that resist proposed changes rather than enabling them (Beetham et al., 2008). Additionally, empirical studies on the effectiveness of participatory approaches in reaching consensual decisions remains inconclusive (Bosher, 2014; Lin and Erickson, 2008; Marshall, 2010; Marshall et al., 2011; Mozumder et al., 2011). As such, in order to determine how beneficial participatory processes can be in practice, there needs to be clarity regarding the type of stakeholders involved, how interactions take place, and what specific decisions are sought (Fung, 2006).

Perhaps the most important consideration for resilience research is that participatory approaches exhibit value pluralism (Kekes, 1993) since the point of engaging stakeholders is to diversify the knowledge-base for decision-makers. This diversification is achieved either by the stakeholders directly participating in the decision process, or that their contributions are incorporated by decision-makers. If however, there is a high degree of connectedness and shared values among stakeholders, this could be an indication that decisions might not reflect what the overall population wants (Pfefferbaum et al., 2008). Some have argued that the reason why community participation cannot achieve desired effects is due to state dominance of governance (Stark and Taylor, 2014); however, as mentioned earlier in the case of elite capture, the “community” itself may be part of the problem. In reality, participation in local decision-making is frequently dominated by the “usual suspects” (Taylor, 2003). They are usually politically engaged individuals, or even active protesters, who tend to have very strong opinions about particular topics relevant to their local context (Harrison and Singer, 2007). The influence of these “usual suspects” is augmented because decisions in participatory bodies are not “one-off” affairs (Beetham et al., 2008), but require continuous engagement for a lengthy period. As such, there is significant risk that participation becomes an exercise in attrition, in that only those with enough time and interest in the topics attend and make decisions in the end (Thompson, 2008). For example, Pickering is held as a good example of how local participation can lead to better outcomes (EA, 2016; NFRR, 2016); however, browsing through project reports for *Slowing the Flow* reveals that local stakeholders all come from two local bodies: the Pickering Flood Defence Group (PFDG) and the Pickering and District Civic Society (P&DCS). This puts to question whether a) they in fact represent a group of "usual suspects" as formulated by (Taylor, 2003), and b) whether “elite capture” is taking place (Dutta, 2009).

If participatory bodies comprise exclusively the most politically active, then there would be little to distinguish them from “policy communities”, where policies are determined by those most affected, most interested, most expert or most sentimentally attached to the issue (Atkinson and Coleman, 1992; Cigler, 1990). Ideally, such policy communities function as a consensual body that can respond to issues in a flexible and effective manner. But they can also be exclusionary gatherings that make decisions of political consequence without having any democratic accountability (Hay, 1998). Policy communities in the UK for example have historically tended to be stable coalitions, with substantial agreement between participants, that allows little room for dissenting perspectives (Jordan and Maloney, 1997). If participatory bodies were to show similar isolation, then there is potential that decisions would be the result of “group-think” and systematic bias from the participants (Baron, 2008), rather than the integration of diverse knowledge-sources. It is therefore important to establish clarity on who is engaged in these local participatory bodies, because care needs to be taken not to confuse public participation with political activism.

Participatory bodies do not exist separately from the overall political system

In addition to specifying who participates, it is also important to make clear where the participatory body fits into the overall political and policy system. Why the question of contextual fit matters can partly be inferred from experiences in a particular field of participatory decision-making known as participatory budgeting (Wampler, 2012). Participatory budgeting first surfaced in the Brazilian city of Porto Alegre when the local Worker’s Party won the mayoral election in 1988. The core idea behind the introduction of participatory budgeting was to give ordinary citizens the ability to make direct decisions on public budgets that affect them (Baiocchi, 2005). It took the form of open, government-sponsored meetings where any citizen could deliberate and (more importantly) vote on specific policies (Wampler, 2012). This approach differed from other participatory methods in that it required citizens to actively deliberate over trade-offs and the allocation of resources to competing needs (Baiocchi, 2005). In this process, technical expertise and inputs from policy practitioners were “made subservient to the popular mandate” (Baiocchi and Ganuza, 2014) so that final policy implementation truly reflected the participants’ vote rather than the opinions of technical experts.

Participatory budgeting is in many ways an ideal representation of the participatory process envisioned in resilience literature. It is theoretically a platform for social learning, where diverse opinions can be voiced and local knowledge is included in final decisions. Since participatory budgeting is open to all, it can also hypothetically lead to more collective actions that allow local stakeholders to assume greater responsibility over their lives and have more ownership of the decisions affecting them. However, reviews of participatory budgeting in Porto Alegre and other Brazilian cities show that the institutional context in which these meetings operated had greater effect on the final policy outcomes than the increased citizen awareness it generated (Baiocchi and Ganuza, 2014). One determining factor was that the participatory open meeting was the only forum through which stakeholders could access government resources (Melgar, 2014). When the Worker's Party was removed from power in 2004, these meetings were no longer as relevant since there were alternative methods for individuals to tap into government resources without having to go through the open meetings, where they might meet resistance or have their demands watered down. Another important factor was that the citizens' meeting had a direct "conveyor belt" channel to the municipal executive body that was protected from ministry interventions (Baiocchi and Ganuza, 2014). This ensured that decisions from these open meetings would be put into practice without government officials having an opportunity to give different inputs. When this direct channel was removed, decisions more strongly reflected institutional needs and preferences than those of the citizens, and the participatory body's usefulness diminished.

In general, participatory decision-making is meant to "spread political empowerment and democratisation" (Cleaver, 1999), and resilience literature clearly envisions participation as a forum where technical expertise and lay knowledge should be used for the co-production of policy decisions (Jochum, 2003). However, participatory processes can also be used as a tool to advance political agendas. For example, governments could potentially use it as a way to improve their cost-efficiency and redistribute responsibilities to participating stakeholders and other beneficiaries (Mees et al., 2016). If this were the case, it would be debatable whether participatory bodies are actually conducive to effective policy-making (Newig et al., 2014) since it isn't clear whether local stakeholders alone have the requisite technical knowledge needed to formulate informed opinions about complex problems (Foot, 2009). Detailed understanding of technical issues can be crucial for effective participation in certain policy fields such as flooding, which straddles the boundary between politics and science (Atkinson and Coleman, 1992; Reber, 2007). If there is no source of expertise among the participants, and technical language isn't made explicitly understandable, then it is doubtful whether participatory processes can deliver straightforward decisions to guide policy implementation. Basically, there is currently no acknowledgement in resilience literature that the purpose of a participatory body is crucial for its added value to practical policy-making. They can be effective tools for securing needed stakeholder buy-in and ensure that decisions reflect actual needs of of the local population; however, their ability to deliver effective policy recommendations is far more equivocal.

Furthermore, if the objective of participation is truly to allow stakeholder inputs to be incorporated into final policy decisions, then it should also be made explicit what happens when participants' choices differ from those of technical experts. This is highly relevant because experiences in participatory budgeting have shown that these bodies do not necessarily make decisions that reflect what researchers and technical experts consider to be the most useful or needed (Franklin et al., 2009; Lerner and Secondo, 2012; Stewart et al., 2014). Resilience literature seems to assume that participatory decisions will always result in desirable outcomes due to knowledge-sharing and improving social links that help bridge disagreements. However, should there be disagreement between practitioners and the community, but the implemented policy ends up reflecting the technical experts' preferences rather than the participants' choices, then the community will essentially have been informed of potential policies, without contributing any impactful input in their formulation. Under such a scenario, it would be fair to question what the added value of a participatory method is, since an equivalent outcome would have been just as easily achieved through a standard public consultation exercise.

Basically, a more nuanced perspective of participation is needed because resilience research often depicts a somewhat simplistic picture of the policy process. Rather than a binary choice between collaboration or central control, the reality of FRM in the UK is that a multitude of actors, both local and national, are involved in some capacity (NAO, 2011). Most of them take part in participatory forums that fully or partly fulfil the criteria set forth in resilience literature. These are local bodies where multiple actors, operating across several scales, come together and deliberate and make decisions about issues relevant to FRM (Penning-Rowsell et al., 2013). All of these interactions have not necessarily made FRM less fractious however (Nye et al., 2011), or led to significant changes in strategy.

4.3 Study of local participatory bodies around Pickering

4.3.1 Method

This section will study if institutional and political context influences the role and functioning of local participatory bodies. This is done by providing an overview of the various participatory bodies that fulfil some role in FRM of the area in which the *Slowing the Flow* project was implemented. This was done through desk studies of board and/or committee meeting agendas and minutes from each local body from January 2014 through February 2016. This period coincides with the concluding phase of the *Slowing the Flow* project and also takes into account the 2015 winter floods that affected the project area. Some of these documents are available online, whereas others were obtained by submitting Freedom of Information (FOI) requests to the relevant host organisations. The goal of the desk study was to answer the following questions:

1. Who are the active participants?

2. What are the main issues discussed, and what decisions are made?

3. Is there information and knowledge diffusion from other bodies and initiatives relevant to FRM such as the *Slowing the Flow* project?

Finding out who the participants in these local bodies are serves the dual purpose of determining whether the assemblies can be categorised as participatory by the specifications in resilience literature. It also serves to check if there is any overlap in membership between the assemblies that might facilitate knowledge-sharing.

Analysing the discussions and decisions helps determine whether policies are aligned between the various participatory bodies. Importantly, it serves to give an idea of whether these committees share similar perspectives on how to handle FRM, or whether they are largely guided by the institutional and legal frameworks in which they operate. Legal frameworks can be particularly pertinent since many participatory bodies are created to fulfil legislative stipulations. Meaning they are obliged to operate within certain constraints put on them through statutory obligations. As such, the nature of their deliberations, and the decisions that are taken, might reflect these considerations more than the ideas and knowledge provided by the participants.

The third question ties in with the previous ones in that the point is to assess whether cross-pollination of ideas occurs. Since there are already a number of participatory bodies in the case study area, if there is little synchronicity between these bodies, then the claim that a participatory process will automatically lead to greater cohesion and better incorporation of diverse knowledge would be questionable.

Also, as has been mentioned in previous chapters, the issues of scale and finding suitable definitions for what is meant by “local” (or “community”) affect both the structure, and the findings of the study. The definition of “local” used in this study is largely guided by the way in which FRM is structured in the UK, where the lowest level of “granularity” is essentially at the county district level. Therefore, the local population – or community – is defined as residents who live within Ryedale district. This is obviously an imperfect definition since a single flood event can cross over multiple districts for example. However, it has been chosen because of it being the lowest level of granularity for policy implementation, and thus the most immediate level at which residents and local populations can engage with policy makers and practitioners.

4.3.2 Analysis

The main participatory bodies involved with FRM in the area around Pickering are:

- Ryedale District Land Drainage Liaison Group (LDLG)
- Vale of Pickering Internal Drainage Board (IDB)
- North Yorkshire County Council (NYCC) as LLFA
- Yorkshire Derwent Partnership Board (YDPB)
- Yorkshire Regional Flood and Coastal Committee (RFCC)

The IDB and LDLG perform virtually identical functions. The difference being that the IDB is a self-governed public body with its own board, whereas the LDLG is hosted by the local Environment Agency office, and only serves to co-ordinate drainage and channel maintenance activities in Ryedale District.

IDBs are only established in areas of special drainage need, and are given permissive powers by the Environment Agency to provide land drainage and water level management within their local areas (ADA, 2013). It is via these responsibilities that they also deal with matters affecting flood risk. They fund these activities by charging a drainage rate from local agricultural properties and land owners, as well as from a special levy issued to district or local authorities located within their district. Since IDBs are self-governing, they are managed by a board consisting of elected members of the public that are local drainage rate payers, and members appointed by the local authorities (ADA, 2013).

The Flood and Water Management Act 2010 created LLFAs, which are either unitary authorities or county councils. LLFAs are responsible for developing, maintaining and applying an overall strategy for local flood risk management in their areas and for maintaining a register of flood risk assets. As such, theirs is a more strategic and co-ordinating role than other local FRM bodies. The NYCC is the LLFA for the area in which Pickering is situated. They do not have a special committee for handling FRM matters, but rather performs their duty by being represented at various bodies that carry out direct maintenance and work. Within the NYCC, the committee most responsible for FRM matters is the Transport, Economy and Environment Overview and Scrutiny Committee (TEEC).

YDPB is probably the entity that most closely resembles a participatory body as described in resilience literature. The Partnership is co-hosted by the East Yorkshire Rivers Trust and

Yorkshire Wildlife Trust, and membership consists of experts and policy officers from local water management bodies. The Partnership does not have its own source of funding, and therefore serves mostly a co-ordinating and information-sharing capacity.

The Yorkshire RFCC is one of eleven such bodies created through the Flood and Water Management Act 2010. They are responsible for ensuring that coherent plans are in place for managing flood and coastal erosion risks across catchments and shorelines in England. Perhaps their most important role however, is their capacity to raise local levies used to fund targeted investments in FRM initiatives. As such, they are both a co-ordinating body capable of linking local initiatives with wider national actors, as well as an important source of funding for local FRM projects.

Table 4.2 shows an overview of the characteristics of each body.

Ryedale LDLG and Vale of Pickering IDB

The two local drainage groups – Ryedale LDLG and Vale of Pickering IDB – made almost no mention of the *Slowing the Flow* project during the time period studied. The pilot project was mentioned once at a LDLG meeting in early 2015 when construction of the low-level water storage bund at Newbridge was nearing completion. This is somewhat surprising since the Ryedale LDLG is hosted by the Environment Agency, which was also heavily involved in the implementation of the pilot project, and contributed funding to build the low-level bund. Furthermore, the two drainage bodies had members who were also part of the *Slowing the Flow* Delivery Group and therefore would have personal knowledge of the pilot project plans. This would suggest that while the participants were likely to be aware of the pilot project, they did not consider it relevant for carrying out their responsibilities.

The discussions, particularly in the Vale of Pickering IDB, centred primarily around questions of an operational nature such as adjustment of drainage rates or carrying out of scheduled drainage and maintenance work. This is understandable since the raising and expenditure of levies is likely to be an issue of great interest to the local farmers and land owners. It is likely that such matters are of interest to the board members as well since they have a statutory obligation to carry out such works, and the elected members are themselves local farmers or land owners. Also, the fact that the IDB is the only local participatory body with elected members of the public is particularly interesting. Board members on the IDB are elected on an annual basis by individuals who pay drainage rates, so mainly local landowners and farmers. By having these elected members, it could be argued that the IDB

Table 4.2 Summary characteristics of participatory bodies

	LDLG	Pickering IDB	NYCC - TEEC	YDPB	YRFCC
Category	Collaborative	Collaborative	Consultative	Consultative	Collaborative
Operating scale	District	County	County	Regional	Regional
Participants	RDC, EA, IDB, NYCC, NFU, members of the public	NFU, RDC, SDC, elected members of the public	NYCC, members of the public	EA, County Councils, FC, NFU, RFCC, NYMNPA, Yorkshire Water	County Councils, EA, IDBs, Yorkshire Water, engineering companies, academics
Source of funding	RDC, NYCC, IDB	Drainage rates and special levies	DCLG, Local Service Support Grants	Limited funding, Natural England, Local Councils	Local Levy
Most relevant Acts of Government	- Land Drainage Act 1994	- Land Drainage Act 1994 - Water Resources Act 1991	- Flood & Water Management Act 2010 - Highways Act 1980 - Town & Country Planning Act 1990 - Localism Act 2011	- Water Resources Act 1991 - EU Water Framework Directive	- Flood & Water Management Act 2010
Main objectives	- Maintenance of rivers, drainage channels, and pumping stations	- Maintenance of rivers, drainage channels, and pumping stations - Some environmental protection duties	- Lead Local Flood Authority - Strategic oversight of local flood risk management	- Habitat protection and conservation - Assist local authorities with conservation measures - Support and fund scientific studies	- Funding decisions for various local projects - Some degree of monitoring and knowledge-sharing of ongoing projects - Used as a link with national bodies such as Defra for information-sharing and deliberations
Mentions *Slowing the Flow*	Yes	No	No	Yes	Yes

Acronyms: Ryedale District Council (RDC), Environment Agency (EA), National Farmers' Union (NFU), Scarborough District Council (SDC), Forestry Commission (FC) is the participatory body whose deliberations and decisions are the most representative of the views held by the local population it serves. The habitual nature of the meeting discussions appear to suggest that simply including local representatives does not necessarily lead to diverse problem perceptions and information-sharing. Rather, those who participate seem to be those most interested in ensuring that the IDB continues to operate in largely the same manner as it has always done. In short, participants from the local community appear to behave more like vested interests, rather than the proactive partners who support policy change, envisaged in resilience literature.

Additionally, an issue that is worth noting is the funding structure of IDBs, which can perhaps give a partial explanation for why it can be difficult to convince farmers and land owners to sign up for NFM schemes like the initiatives proposed in *Slowing the Flow*. If their land is situated within the management area of a local IDB, farmers/landowners are automatically obliged to pay an annual drainage levy. This levy still gets charged even if they implement NFM measures on their land. Essentially they would be required to pay a charge in order for their land not to be flooded, even while implementing measures so that it can be flooded.

North Yorkshire County Council – TEEC

NYCC TEEC meetings held during the relevant time period did not mention the pilot project at all. In fact, the only time any issue relevant to FRM was brought up was in October 2014, when the committee discussed work on drafting the North Yorkshire Local Flood Risk Management Strategy. As an LLFA, the NYCC is required to provide such a strategy document by the Flood and Water Management Act of 2010. Based on the paucity of FRM matters raised before the committee, it appears that it is not a prioritised issue for the NYCC.

The overwhelming majority of matters raised concerned road maintenance and other relevant infrastructural issues. It was clear that road works were the most highly prioritised part of the committee's work given that the local FRM strategy only received cursory comments from the councillors, whereas discussions about roads went into minute details of costing and operational issues. Interestingly, while committee meetings are always open to the public, the only times members of the public were actually in attendance were when the reduction of bus service subsidies was discussed. The potential of raised bus fares was clearly a very visible issue for many local residents since they would have to pay for higher fares out-of-pocket. This is in contrast to FRM related costs, which are mostly hidden, and not considered by the public until their homes are flooded (Bosker et al., 2014; Wright et al., 2011). A possible question to ponder then, is if this reflects Harrison and Singer (2007)'s argument that those who are actively engaged in technical issues like FRM will also be those who are already politically active and have formed very strong opinions about the topic. If this is the case, then a participatory forum might not be conducive to informed, open discussions, since participants are likely to approach such meetings with entrenched positions.

Yorkshire-Derwent PB

The YDPB is probably what resilience researchers have in mind when they envision a participatory process. The Partnership consists of a multitude of actors who operate across multiple spatial scales. The meetings comprise mostly of information-sharing of different experiences from the participants, and serve as a platform for establishing links and networks between these actors. The individual goals for each participant seem to consistently be about gaining more knowledge in order to become better at performing their responsibilities. However, while FRM initiatives such as *Slowing the Flow* are regularly discussed, the main focus of discussions centre around habitat preservation and wildlife conservation measures. In fact, FRM is almost exclusively discussed in relation to the usefulness of NFM measures for advancing habitat preservation objectives.

It is probably because it does not raise its own funds, or have any statutory obligations to carry out, that the YDPB can be used for information-sharing purposes rather than for making decisions on recurring agenda items. Since it does not fund any initiatives or works, the YDPB is essentially free from outside forces exerting pressure on their decisions. Also, because it is free from performing statutory operational duties, the Partnership is able to function in a less structured format that is conducive to greater deliberation and more knowledge-sharing. Also worth noting is that despite having members from the Environment Agency, NFU and NYCC, there was no cross-pollination of ideas between the YDPB and the more local bodies mentioned above. Aside from the *Slowing the Flow* project, nothing that was discussed in the Partnership during this time period was ever mentioned at the meetings of the more local participatory bodies. It is unclear why this is the case, but one possible explanation could be that the other local participatory bodies do not provide an obvious platform to discuss these more conceptual issues. The meeting objectives for these participatory bodies are primarily aimed at finding appropriate and feasible ways to carry out their obligations, which leaves little room for the intellectual exchange of ideas envisioned in resilience literature.

Yorkshire RFCC

The meetings of the RFCC mainly concern allocating funding for various FRM initiatives within its jurisdiction. This is unsurprising since the RFCC, with its ability to issue local levies, is the main source of funding for FRM projects aside from the Environment Agency and Defra. While there is occasional discussion about the progress of projects like *Slowing the Flow*, deliberations are mainly limited to funding matters and deciding on what projects to finance. Interestingly, even though the RFCC is meant to serve the dual purpose of ensuring coherent FRM plans as well as providing targeted investments for FRM, it is the second objective that occupies the vast majority of time at meetings. One possible explanation for this could be that unlike at the Environment Agency or Defra, proposed FRM initiatives do not have to compete with other projects across the country for funding. As such, the RFCC is a useful source of financing for smaller local initiatives that have little chance of securing national funding. Consequently, although the RFCCs were conceived as a group that provides more strategic oversight and guidance of local FRM issues, the reality seems to be that the acute funding demands have resulted in the committee shifting focus towards more operational matters.

Cross-cutting issues between local participatory bodies

Based on the meeting minutes of the participatory bodies that were studied, only the Yorkshire RFCC had a demonstrably informed knowledge of some of the activities at other local bodies. This is despite the fact that there is membership overlap between almost all of them (with the NYCC-TEEC being the notable exception). The Environment Agency is represented in almost all the groups for example, and representatives from the NFU participate in three of the five groups. For some organisations, such as the Environment Agency, Ryedale DC, and Vale of Pickering IDB, it is even the same individuals that participate in the different groups (specifically, LDLG, Vale of Pickering IDB, and YDPB). The lack of co-ordination between these local participatory bodies is most likely because their objectives, and therefore the purpose for holding meetings, vary greatly. The YRFCC is well informed of activities at other bodies because their purpose is to provide funding for some of these activities, and being informed about them is part of the regular functioning of the body. The other local bodies do not need this knowledge to perform their tasks. So even though there may be overlap in participants, knowledge-sharing is not essential for them to perform their designated obligations.

The contrast between the YDPB and the other participatory bodies suggests that their functioning is highly dependent on political and institutional frameworks. The Vale of Pickering IDB and the Yorkshire RFCC for example, have very structured meetings because their function within the institutional framework is to raise funds and carry out (IDB), or finance (RFCC), water management works. There is very little room for deliberations at their meetings because they are primarily concerned with matters related to these obligations. Similarly, FRM is only one of the policy areas in which the NYCC-TEEC has to have oversight. They are therefore primarily concerned with issues that require the most local spending and grab the most regular public attention, which happens to be road maintenance. By contrast, the YDPB has no statutory obligations to perform, nor does it need to concern itself with allocating funding to competing interests. It is therefore free to adopt a much more deliberative process that is less structured and formulaic than the other participatory bodies.

4.4 Survey of local community members

4.4.1 Method and sampling process

The second part of this study is intended to find out whether *elite capture*, and the possibility that local participation is simply an exercise in involving the *usual suspects* is indeed an issue. The study was carried out using a survey questionnaire that was designed in the Qualtrics Research Suite tool. The specific sample of respondents were collected by initially reaching out to suitable contact persons given by Environment Agency and Forestry Commission officers who were involved in the project. I then asked these contact persons to distribute to their members via group mailing lists. The members were free to reply on a voluntary basis by simply clicking on a link to the questionnaire provided in the email that was distributed. There was also a free-form comment section included at the end of the survey, where respondents could write down thoughts or input that was not included in the survey questions, if they wished to do so.

The sampling process is somewhat unique in that the targeted population is specifically those who live in area surrounding Pickering, where the *Slowing the Flow* project took place. As such, the survey uses a targeted method that involves non-probabilistic sampling (Patton, 2005), which unlike probabilistic sampling, does not assume to have a response that is representative of the overall population (Merriam and Tisdell, 2016). The choice of a non-probabilistic sampling method is motivated by two factors:

1. Practical limitations on the possibility of conducting probabilistic sampling of the target population
2. The objective is to gain insight of possible existence of *elite capture* and so-called *usual suspects*

In terms of the practical limitations, the main issue was identifying and surveying a sufficient number of people that were suitably representative of the local population, as to allow generalisation of the survey results. This challenge proved insurmountable given the funding and time constraints of my study, which is a strong contributing factor for choosing targeted sampling. This approach obviously limits the kind of inferences that can be drawn, and they will also need to be carefully considered.

Additionally, since the objective of the survey is to identify the possible existence of *usual suspects* that could lead to problems with *elite capture*, non-probabilistic sampling is arguably more useful (Merriam and Tisdell, 2016). A non-probability sampling method is useful because the data is not used to extrapolate information about characteristics of the general local population, but rather to discover and gain insight about specific cases at the local level. The survey focusses on individuals who are active in local community groups and charities, and attempts to find out what their views on certain key issues surrounding FRM are. This may then inform if there is a risk that participants in these local initiatives may offer biased views of policy initiatives such as NFM. It should be stated here that this type of non-probabilistic sampling assumes that membership in certain groups is extendable to engagement with policy initiatives. This means that individuals involved in local civic societies or charities, for example, are more likely to be actively engaged with government policy initiatives than individuals who participate in a local football club.

While the PFDG and the P&DCS were the two local groups that were intimately involved with the *Slowing the Flow* project, they do not necessarily constitute the only local organisations that are engaged and have input in local policy initiatives. Limiting sampling to these two organisations could then potentially result in the sample population consisting of individuals who are interested in *Slowing the Flow* in particular, rather those with a general interest in local policy initiatives (which is the targeted sample population). Therefore, as a referencing exercise to see if any other groups could be engaged in policy-related activities in the Pickering area, I also browsed through the local Community Directories (consisting of registered local charities and community groups) maintained by North Yorkshire Council, Ryedale District Council, and Pickering Town Council. This search returned no other registered community group that are engaged in policy-related activities. As such, while the survey sample is not necessarily representative of the overall local population, it is likely to be fairly representative of local stakeholders who are actively interested and engaged in policy-relevant processes.

Overview of survey

1. How did you hear about the *Slowing the Flow* project?
   (a) I participated in project meetings
   (b) By word of mouth or council newsletters
   (c) Through local or national news
   (d) I don't know about the project
2. Do you think the natural flood management measures implemented through the *Slowing the Flow* project have been effective for preventing flooding?
   (a) Yes
   (b) No
   (c) Unsure/Undecided
3. Do you think the area around Pickering needs solid flood defences (dikes, flood-walls, flood sluices etc.) in addition to the natural flood management measures already in place?
   (a) Yes
   (b) No
   (c) Undecided
4. Who do you think should be responsible for funding flood risk management and flood defence measures?
   (a) National Government
   (b) National and Local Government
   (c) Local Government through levies
   (d) Private citizens
5. Have you taken measures to flood-proof your home (flood shields, cavity sealing, moving electrical sockets etc.)?

(a) Yes

(b) No, but I intend to

(c) No, I don't intend to, or I can't afford it

(d) My home is not at risk of flooding

6. In what order would you rank these political issues in terms of their importance for your community?

(a) Affordable Housing

(b) Abolition of District Councils

(c) Flooding

(d) Fracking

(e) Road and other infrastructural improvements

7. Which political party do you support or identify with the most?

(a) Conservative Party

(b) Liberal Party

(c) Liberal Democratic Party

(d) Labour Party

(e) Other, or no party affiliation

8. Are you a member of an environmental organisation such as the National Trust, RSPB, Wildlife Trust, Friends of the Earth etc.?

(a) Yes

(b) No

9. Do you work in the agricultural sector (i.e. growing crops, raising livestock, fisheries management etc.)?

(a) Yes

(b) No

The survey questions were kept deliberately short and general enough as to not require detailed technical knowledge. This was done to avoid any specification error in the responses, meaning a respondent selects an answer that does not reflect their actual opinions because they did not fully understand the question. Another consideration in designing the survey was putting the political affiliation question towards the end in order to avoid reference group effects, where a respondent selects answers they think corresponds with their given political affiliation (Saris and Gallhofer, 2014). Also, the political party options in question 7 are a reflection of the local political context, where for example, the Liberal Party has a much stronger presence than they do nationwide. The stated political parties are the ones that managed to secure a seat on the Ryedale District Council at least once over the past three local elections in North Yorkshire (2017, 2013, 2009)[1].

Questions 1-5 are intended to gauge whether local problem perceptions have aligned more with those of FRM experts as a result of the *Slowing the Flow* project. The point is to ascertain if potential new knowledge makes local residents more inclined to favour different methods and practices for FRM. If opinions do not change, and there is lingering disagreement on how best to approach FRM in the Pickering area, then arriving at consensual decision-making through participatory processes may be more difficult than envisioned in resilience literature.

Questions 6-9 are meant to give an idea of whether *elite capture*, and the risk of participants consisting of the *usual suspects* is a potential risk in the Pickering area. As mentioned earlier in this chapter, continuous engagement with policy practitioners necessitates sufficient time and interest on behalf of the participants. Therefore, those most likely to participate are probably also those in the community with the most personal interest in the topic. If their participation constitutes a risk for potential elite capture, then it would be fair to question whether these participatory bodies are suitable mechanisms for getting useful local input for decision-making.

4.4.2 Analysis

The total number of respondents to the survey was 19, which is roughly the expected figure since the survey was sent out to the mailing lists of two local community groups. Knowing that the respondents comprise a relatively small sample size, and specifically represents a sub-group of the local population, care must be taken to avoid drawing inferences that are too broad to be supported by the data obtained. Keeping this in mind, the findings from the survey can still be potentially very useful since both the Pickering Flood Defence Group and

[1] It is worth noting that an “Independent” or “Other” affiliation in Ryedale more than likely indicates that the person in question normally self-identifies as “Conservative”. Their “Independent” status is likely caused by a political rift in the local Conservative party, which occurred in 2013.

the Pickering Civic Society had representatives involved in the *Slowing the Flow* project, meaning it is likely that their members are more inclined to be interested in FRM issues. Therefore, the results could offer an indication into whether local participants indeed are self-selecting, and part of a group of *usual suspects* suggested by empirical research on participation in other policy fields. This in turn can help determine if participatory processes indeed can strengthen local awareness of and influence on policy decisions as theorised in resilience literature, or whether they are used as forums for political activism.

Another issue to keep in mind for the analysis is that the response rate is somewhat unclear. The PFDG did not provide any figures on the total number of members in their mailing list. The P&DCS indicated that they have 43 members in their mailing list, but only roughly half of those are active on a regular basis. It is also possible that there is some degree of cross-pollination between the two groups, meaning one individual can be a member of both groups. Because of the uncertainty surrounding the actual membership numbers of both bodies, it is difficult to determine what the response rate of the survey was. By extension, there is also some ambiguity regarding how representative of the sample population (e.g. local population actively interested in local policy initiatives) the survey is. These issues also need to be taken into consideration during the analysis.

Questions relevant to social learning and information-sharing

One of the questions of this study is whether any learning takes place through local communities participating in the policy implementation process. Linked with this question is whether community perceptions are then aligned with those of technical experts and policy officers involved in FRM, in particular the *Slowing the Flow* project. Regarding the issue of learning, it is evident from the replies that the pilot project has been very successful in raising local awareness. All 19 respondents knew about the project and had heard about it either through personal involvement or been informed by someone they knew or a regular community newsletter.

An issue that became apparent while studying policy documents and conducting interviews with involved practitioners for the *Slowing the Flow* case study in chapter 3, is that a potential flood alleviation scheme for the Pickering area was rejected by the Environment Agency in 2007 due to the project not fulfilling cost-benefit criteria. Hence, when the *Slowing the Flow* project was proposed in 2009, the local reaction was that they were offered a "second-best option", as one local stakeholder put it. It is unclear whether their reaction reflected actual doubts about NFM measures, or whether it was due to disappointment that the costlier option had been rejected. Results from the survey suggest that it may be a mixture of both sentiments. Twelve of the respondents think that NFM measures are effective at preventing floods, while seven are undecided, and none think that they are not effective. Meanwhile, 15 respondents also think that the area needs more flood defence measures installed in addition to the pilot project NFM measures, with the four remaining people undecided on the issue. Based on the replies, it would seem that respondents are largely in favour of NFM measures, perhaps as a result of the bund successfully preventing the town from being flooded in the 2015/16 Winter floods (EA, 2016). However, they still have lingering doubts about <u>how</u> effective they can be in preventing floods. One comment left a by survey respondent encapsulates this lingering ambivalence:

> *"We like the bund. Especially because it doesn't change the local landscape much. This is important for the local tourism industry. But it only prevents a one in 25 year flood. We are still not protected against larger floods."*

While opinions about the efficacy of NFM measures may potentially have aligned as a result of the pilot project, a possible divergence in opinion between respondents and policy practitioners can be gleaned from the responses regarding the issue of funding. To the question of who respondents think ought to be responsible for funding FRM measures, an overwhelming majority (15 people) thought that the National Government should do so, and the remaining four thought that the National Government and Local Government should have shared responsibility. None were of the opinion that Local Government or private citizens should be responsible for FRM funding. The question of funding is of fundamental importance since one of the main reasons why the pilot project at Pickering was approved was due to the desire to explore more cost-effective options for FRM. For policy practitioners, *Slowing the Flow* was meant to provide concrete evidence whether NFM measures could be satisfactory alternatives to traditional FRM methods in sparsely populated areas, where "hard" flood defences simply did not satisfy cost-benefit analyses. Therefore, the pilot project was meant to provide input for necessary trade-off calculations.

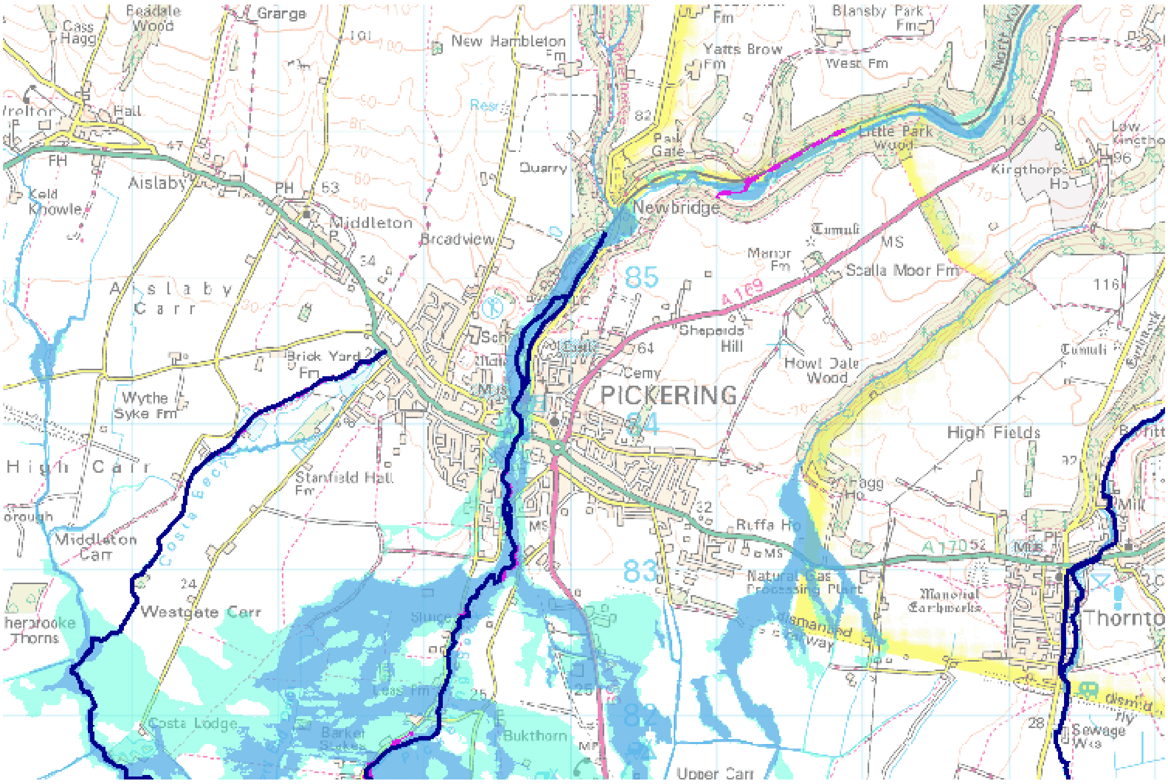
The respondents obviously do not make these trade-off calculations in their approach to the problem. In believing that it is the National Government's responsibility to provide funding for FRM, they evidently do not see flooding as a local problem for which they need to take "ownership". With this in mind, they would appear to act more like a special-interest group rather than partners engaging in dialogue and knowledge-sharing with FRM practitioners in order to co-produce policies. From the perspective of the respondents, FRM appears to be a matter of getting as much funding from the Government as needed in order to make their area completely protected from flooding. If the respondents' sentiments are shared by the overall community, then they would be merely one among a plethora of groups competing for a share of the Treasury pot. As such, the structure for a participatory process between the local community and policy practitioners never truly goes beyond a transactional stage, where the Government is the provider, and the community are the recipients of FRM measures. In such an arrangement, mutual dialogue can be productive, but would still be limited to one side asking for as much as is realistic, and the other side giving as little as would be acceptable.

Questions of *elite capture* and possible *usual suspects*

The question about flood-proofing homes is interesting because it is an indication of how likely a respondent is to be personally affected by flooding. As the Environment Agency flood zone map of Pickering in Figure 4.1 shows, only properties in the immediate vicinity (highlighted in blue) of Pickering Beck are actually at risk of flooding. Therefore, only a minority of residents in the community would even need to install such measures. With this in mind: (1) eight respondents indicated that they have flood-proofed their homes, (2) three intended to do so, (3) five suggested that they did not need, or could not afford to do so, and (4) only three respondents said their home is not at risk of flooding. These results suggest that the group surveyed may not be entirely representative of the community as a whole, since the flood zone map shows that a majority of the town is not at risk of flooding. If the groups are indeed disproportionately affected by flood risk in comparison with the general local population, then it would also be relevant to question how reflective their input is of the overall opinion in the community if they were to contribute to local FRM policies. There would be little point to organising a participatory process with the objective of obtaining local inputs, if it turns out that the potential participants might not be speaking for the entire community.

Another indication of the potential risk that respondents from the PFDG and P&DCS may represent a group of *usual suspects* can be deduced from their membership in environmental organisations, as well as their party affiliations. Fifteen of the people surveyed replied that they were members of an environmental organisation. This is an eye-catching number, since according to a report published by the Environmental Funders Network, about 4.5 million people in the UK are members of an environmental organisation (Cracknell et al., 2013). This number may be slightly higher today, since the National Trust indicated that they alone had membership numbers totalling 4.5 million in 2016 (NT, 2016). However, the total number of people in the UK who are members in an environmental organisation is unlikely

Fig. 4.1 Pickering Flood Zone Map

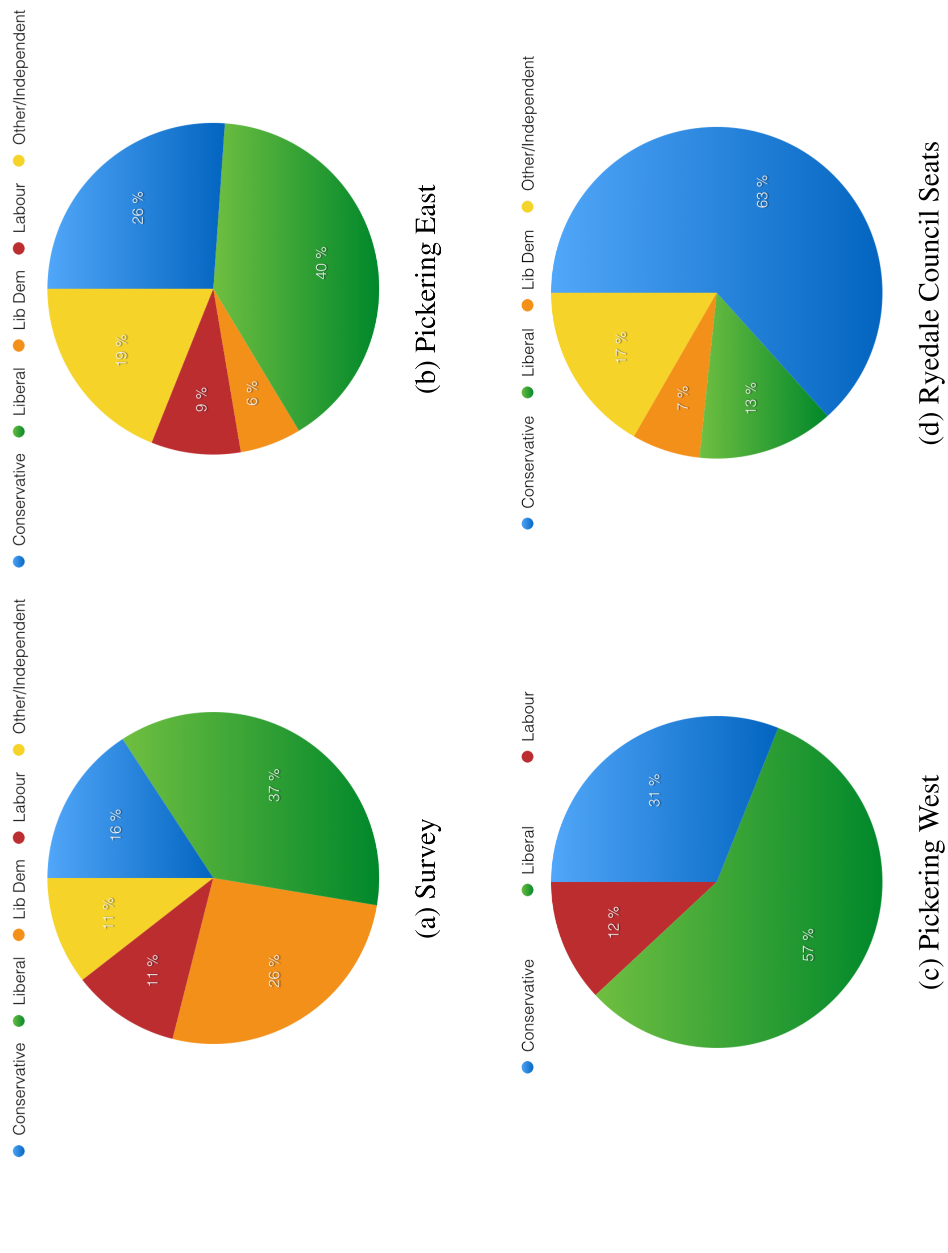


to exceed 10% (6.5 million) of the overall population. By contrast, fifteen out of nineteen survey respondents are members of an environmental organisation. While Pickering, as a rural tourist destination in close proximity to a national park, probably has higher relative membership figures than the general population of the UK, it is highly unlikely that they would differ so drastically from national numbers. A more plausible explanation is that members of the two community groups are more likely to have an interest in environmental issues than the general local population. This could possibly mean that their interest in FRM issues is part of a wider engagement in environmental matters, making them more similar to Taylor (2003)'s *usual suspects*, rather than the local partners envisioned in resilience literature.

Further indication of possible differences between the members of the two community groups and the overall local population can be gleaned from the charts in Figure 4.2 detailing party political affiliations. The two most noticeable results are that the Liberal Democrats are overrepresented among respondents compared with the general local population, and the Conservatives are somewhat under-represented. Part of the discrepancy in support for the

Liberal Democrats may be due to practical factors, such as the party not having a candidate in the Pickering West ward for the 2017 local elections. As such, voters who otherwise would normally vote for them may have cast their ballots for the Liberal Party candidates instead. However, it is unlikely that this explanation would account for such a large discrepancy. Also, this would not explain why the Conservative vote is under-represented among survey respondents. The relatively low support for the Conservative party among the community groups' members is particularly glaring when compared with Ryedale District Council seat allocations following the 2017 local elections. Since flooding is a district-wide concern rather than an issue unique to Pickering town, a local participatory body ought reasonably be representative of the affected area as a whole. Given the information summarised in Figure 4.2, it remains unclear whether members of the two community groups involved with the *Slowing the Flow* project can be considered representative.

Fig. 4.2 Political affiliations in the Pickering area



Note: The numbers in charts (b), (c), and (d) are all taken from the results of the local elections held in April 2017

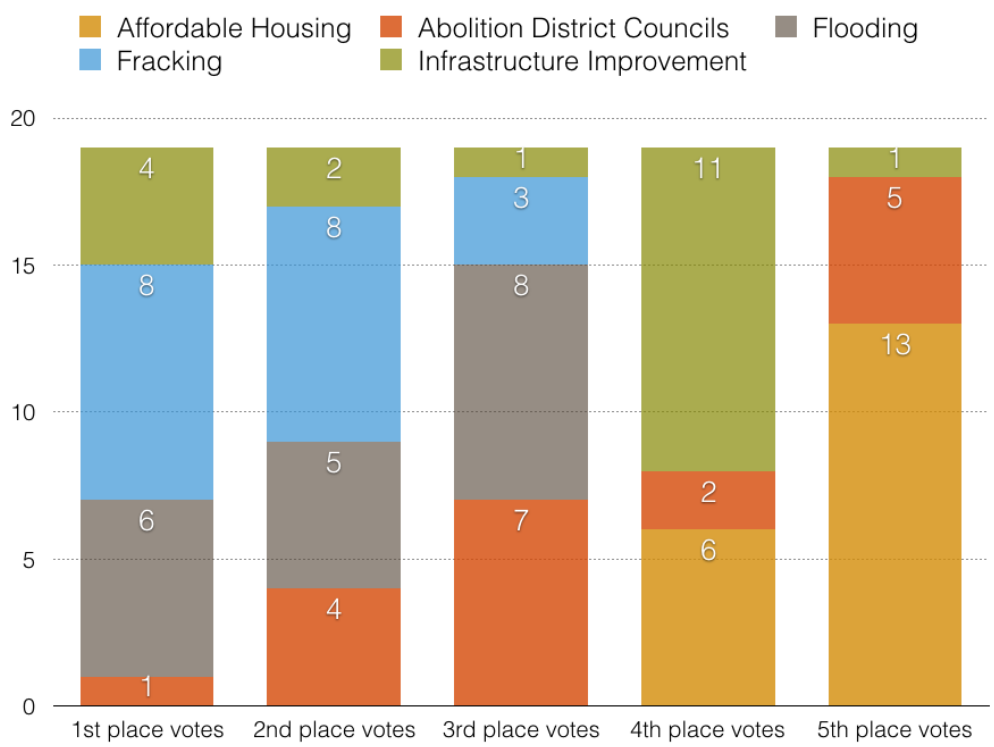
Another issue that is linked with the difference in political leanings between Pickering Town and Ryedale District in general is that none of the respondents works in the agricultural sector. As was mentioned in the previous chapter, the *Slowing the Flow* project had appreciable difficulties engaging local farmers and land owners. Only 12 out of 287 farmers, and none of the private land owners, signed up for NFM initiatives supported by the project. Since none of the survey respondents work in the agricultural sector, they would benefit from any NFM measures put in place without incurring any personal costs. For farmers and land owners however, implementing NFM measures also entails potential income losses. As such, even if they supported such initiatives, deciding whether to approve of NFM measures requires making realistic cost-benefit calculations. Because of their different perspectives, the survey respondents and the farmers and land owners would likely provide very different inputs to any participatory process. While the lack of local landowner representation is not necessarily a reflection of local economic and political imbalances, the issue of *elite capture* is still pertinent. In addition to providing potentially biased input that can be misinterpreted as representing the overall local viewpoint, there is risk that a small group of people take ownership of the FRM issue, and force decisions that may even be to the detriment of certain local populations.

Finally, even though the respondents clearly have an interest in flooding related issues, it might not necessarily be their most pressing concern. For example, in the recent 2017 local elections, the issues that were brought up the most during political campaigning were fracking, road improvements, housing, and abolishing district councils. Flooding was mentioned regularly, but only in conjunction with other environmental concerns like fracking. The question about ranking political issues was therefore included in the survey to gauge whether there is a similar spread in priorities among the respondents. Figure 4.3 summarises how respondents ranked different political issues in order of perceived importance. As can be seen, while flooding may be highly prioritised, it is actually not the most important issue for a majority of the respondents. Fracking is the issue that the highest number of respondents considered the most important for their local community[2]. Combining the results of this question with the earlier question about membership in environmental organisations, it would be pertinent to ask whether the common denominator for the groups is truly a concern for flooding. Perhaps what the respondents actually have in common is a shared concern for environmental issues. This is a meaningful distinction because it also puts into question whether the respondents' support for *Slowing the Flow* is due to its perceived effectiveness in flood defence, or if they are actually in favour of these measures because they also help

[2]Fracking is included as a choice because it is an issue of particular concern in North Yorkshire, where in the local election in April 2017, three parties (Labour, Liberal Democrats, and Liberal Party) set banning fracking as a prioritised issue in their campaigning

environmental preservation, which could be interpreted as a form of *elite capture*.

Fig. 4.3 Political issues in order of perceived importance



In summary, the results from the survey suggest that the question of "who participates" can be a tricky matter. The survey specifically targeted the two local community groups who were engaged with the *Slowing the Flow* project. While the members of these two groups seem to consider the pilot project as a success, the survey results also suggest that the issues of *elite capture* and lack of representativeness (*usual suspects*) may be present in Pickering. The absence of members active in agriculture, their political affiliations, and the general leaning toward environmentalism all point toward a lack of representativeness. Additionally, evidence from the survey suggest that there does seem to be a genuine acceptance of NFM measures as a result of project engagement. However, the respondents still appear to act more like special interest groups rather than true participants as envisioned in resilience literature, since they still strongly believe that FRM is the responsibility of the National Government rather than local stakeholders.

4.5 Findings

The main finding from this chapter is that the use of participatory methods is not a "magic bullet" that can provide diverse interpretations, and informed arguments useful for solving complex problems. While participatory methods may confer clarification, and sometimes even change participants' views, by increasing awareness of complex issues, they do not necessarily deliver clear guidelines for policy implementation. One example from the survey is the contrasting view of FRM funding, where the respondents' answers indicate that they still view the relationship with FRM practitioners as largely transactional. Although the *Slowing the Flow* project had led to a mutual exchange of views, that helped the local community partly adjust their problem perception, they quite obviously still consider the Government to be the main responsible party on FRM matters. Furthermore, it is not evident how local stakeholders might act, were they to be made responsible partners co-responsible for policy decisions, similar to the participatory budgeting examples. The survey suggests that there are a myriad of issues that the local community consider to be important, and they do not necessarily agree on the order of priority. As such, a participatory process that offers local populations impactful input into policy decisions may not deliver more clarity than a more centralised structure. Basically, participatory bodies can be highly effective at collating information and exchanging ideas when used in a strictly deliberative capacity, as is the case of the YDPB for example. However, they will not magically lead to more effective policies, since this is also dependent on the political and institutional context in which these participatory bodies exist.

Additionally, it would be pertinent to ask whether participatory methods are truly a necessary component of policy-making for resilience, or whether their inclusion is merely an exercise in ticking off another box in the good governance checklist. If participation is indeed a core component of the resilience concept, then the functions of participatory bodies need to be more clearly specified so that it remains a procedural tool used to inform decisions, rather than becoming a means to circumvent the normal democratic process (Howlett, 2011). There is awareness in resilience research that political accountability of decisions made by participatory bodies can be problematic, in the case of *elite capture* for example. However, there remains a notable lack of practical detail about how effective and just local participatory bodies can be set-up in practice. There is especially a knowledge gap in how to balance local viewpoints with input from elected public officials in a manner that improves legitimacy and accountability. Meeting documents from the Vale of Pickering IDB for example, suggest that local participants may resemble vested interests more than proactive partners working for policy change. The point is that if a participatory body is given real power to make policy decisions, and it only has participants who are politically active *usual suspects*, then those who might disagree with their decisions would have minimal means of holding the participants accountable, the way that they could of elected public officials.

Furthermore, it is important to recognise the influence of the policy context on the functioning of a participatory body. The differences between the Yorkshire RFCC and the YDPB serves to illustrate the impact of institutional and policy contexts. While the Yorkshire RFCC is responsible for having oversight and co-ordinating FRM initiatives in their region, because it is also responsible for raising levies for targeted initiatives, its role has essentially become that of a funding agency. This is because changes to the FRM policy context in England have made the Yorkshire RFCC's capacity to raise local levies far more valuable to other local authorities than its co-ordinating capacities. The YDPB on the other hand, has no statutory obligations to carry out, and is consequently not as constrained by the policy context. As a result, its members can be far more deliberative, and are free to engage in knowledge-sharing than members of the Yorkshire RFCC. Basically, it is possible that the role of a participatory body can be shaped as much by the policy context in which it exists, as by its participants, or even its original intended purpose.

The findings from this chapter reflect those from the previous one on learning and experimentation, in that participation, as conceptualised in resilience literature, is currently lacking in specific details to be fully practicable in an actual policy setting. Consequently, it seems that neither of the procedural components of a resilience approach provide unequivocal added value for practical policy making. Having dealt with the procedural practicability of a resilience approach in chapters 3 and 4, I will focus on questions of substance, and examine whether phenomena highlighted in resilience literature are useful, and provide new insight, for informing policy decisions.

Chapter 5

Added-value of a holistic approach to resilience - Methods

5.1 Introduction

The previous chapters have focussed on the procedural practicability of a resilience approach to FRM, and whether the policy process envisioned in resilience literature resonates with actual practices. Perhaps more important than procedural matters, however is the issue of substance, meaning the information upon which policies are based. In order to make better (i.e. more effective) policies, it is important that the information being used is relevant for the task at hand, and gives policy-makers a better understanding of the underlying issues that are being addressed. One method for conveying pertinent information to policy-makers, that has been widely embraced in resilience literature (Bergstrand et al., 2015; Birkmann et al., 2013; Winderl, 2014), is the creation of a single measurement of resilience to act as a decision support tool. Measuring resilience is considered useful because: (a) it can be used as a benchmark for performance to determine how effective initiatives are, and (b) help decision-makers identify areas of concern that need to be strengthened (Kotzee and Reyers, 2016). Despite widespread agreement of its necessity, finding appropriate metrics for resilience has proven elusive, and it is frequently stated in the literature that resilience "is notoriously difficult to measure" (Bene, 2013). But part of the difficulty in finding appropriate metrics may be because it is trying to be too many things at once. Current methods for measuring resilience all adopt a holistic approach, and define it as a multi-hazard property, meant to represent a capacity to deal with any contingencies that may occur. It is difficult however (if not impossible), to create a single measurement that can incorporate complexity, interdependence, and uncertainty into its scope as is sought by current methods

(Linkov et al., 2014). By making resilience a multi-hazard property, it becomes necessary to incorporate a wide range of variables that may be either unrelated, or only cursorily related to natural disasters such as flooding. With this in mind, it is pertinent to question whether the measurement difficulties are in fact a problem derived from the manner in which resilience is currently conceptualised, rather than an implicit vagueness of the property.

Keeping in mind the challenges of measuring resilience as a multi-hazard property, the following two chapters will explore the use of socio-economic indicators in existing measures of resilience, and whether these measurements necessarily need to be as complex as current methods suggest. This will be done through statistical modelling, by comparing the efficacy of a socio-economic indicator model, to a control model consisting of various modern FRM measures. Statistical modelling allows for testing and verifying of the links between various indicators and resilience, rather than assuming that such a relationship is self-evident, as is being done in existing indexing methods. By doing this, it may be possible to streamline resilience measurements and make it more practicable for informing policy choices. Using FRM measures as parameters of the control model is motivated by the fact that there is significant overlap between these measures, and those included in current resilience measurements (Sharifi, 2016). In fact, the similarity is so strong that the inclusion of socio-economic indicators is arguably the only meaningful way in which a resilience approach differs from existing FRM practices. More on this issue will be discussed in the overview of the two statistical models in sections 5.3.3 and 5.3.4.

This chapter focusses on the methodological aspects of statistical modelling. Issues that will be addressed include: (a) finding a metric of resilience that is suitable for statistical modelling, (b) determining appropriate subjects to include in the study, and (c) specifying what the parameters of each model will be. The results of the statistical modelling, and the corresponding analysis, will be presented in chapter 6.

5.2 Measuring resilience

5.2.1 Problems with current measurements of resilience

I will not give a comprehensive summary of existing measurement methods, as Cutter (2016) and Sharifi (2016) already provide thorough reviews. Broadly speaking, resilience measurements have tended to fall under three categories: indices, scorecards (or checklist), and self-assessment tools (Cutter, 2016). Almost all of these measurements are intended to be used by practitioners and local stakeholders, which has meant that they are primarily concerned with community factors, rather than infrastructural or institutional ones. Furthermore, existing measurements strongly favour a multi-hazard conceptualisation of resilience, and are designed under the assumption that resilience entails the capacity to prepare for and respond to *any* disaster that may occur (Sharifi, 2016). Keeping this in mind, despite a growing set of literature, and continued widespread interest in resilience metrics, there have been limited attempts at implementing and testing these measurements to assess their adequacy (Prior and Hagmann, 2013; Winderl, 2014). This paucity of empirically proven data is especially problematic for the composite methods (i.e. indices and scorecards) favoured in current measurements, since they are essentially weighted aggregate scores of whatever component indicators are included. Should it turn out that individual indicators do not have a noticeable effect on resilience, then the entire index could be invalidated. What seems to be forgotten in this process is that the end product (i.e. the index) is supposed to be useful for informing policy decisions, by telling policy-makers what needs to be done to improve resilience. In the case of flooding, this requires that the indicators included in a resilience index actually add value by improving the ability to manage and recover from floods effectively.

Additionally, it is unclear why indexing is considered the most appropriate method for measuring resilience. Ideally, any measurement of a phenomenon requires it to be observable, and amenable to systematic attribution of values (Hinkel, 2010; Klein et al., 2003). However, this is unrealistic under current conceptualisations of resilience. Consider the currently most widely used definition of resilience mentioned in chapter 2:

> *"(Resilience is) the ability of a system, community or society exposed to hazards to resist, absorb, accomodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions".*

Creating a measurement that can systematically attribute values across spatial scales (individual to country level), while simultaneously representing disparate properties such as absorptive ability and efficiency is very challenging. Not to mention that it is unclear how to define "accommodation" of natural hazards, or what is included as essential structures and functions that need to be preserved. Simply put, it appears that indexing is the favoured method for measuring resilience, not because of particular requirements of the property itself, but because it is the only option that allows widely disparate factors to be incorporated into a single measurement. The issue of indicator relevance is highly germane to indexing methods in particular, because - as was mentioned in chapter 2 - social vulnerability has become an integral component in current conceptualisations of disaster resilience. For example, it is asserted that deprived communities are disproportionally affected by flood risk (Escaleras and Register, 2008; Lindley et al., 2011), and therefore any measurement of flood resilience needs to include social justice as a key criterion (Thorne, 2014). Because of the emphasis on social vulnerability and justice, current resilience measurements all include a multitude of socio-economic indicators. This emphasis on social justice, and abundance of such indicators, is quite clearly attributable to the hypothesised correlation between socio-economic status and vulnerability to hazards. However, if the goal of measuring resilience is to inform policy-makers what actions need to be taken to improve resilience (Burton, 2015; Sherrieb et al., 2010), then current indexing methods seem somewhat counterproductive. By uncritically including various indicators without first confirming and testing their relevance (to flood resilience for example), the usefulness of these indices is undermined, since their values can be distorted by unrelated indicators that obscure information from the truly relevant indicators. While promoting social justice and improving socio-economic conditions for deprived communities is doubtlessly a worthwhile goal, attempting to address these issues should not result in choosing indicators that are too general, and may not even be relevant for the task at hand.

Furthermore, the criticism that resilience literature has directed at the field of FRM in particular has centred around a supposed over-emphasis on engineered solid flood defence measures, rather than adopting a more holistic approach (Liao, 2012; Toubin et al., 2014). This criticism is not entirely justified however, since modern FRM has mostly embraced "softer" measures such as whole-catchment planning, wetland creation, and floodable land (measures that are espoused in resilience literature) to complement more traditional methods (Gober et al., 2015; Penning-Rowsell et al., 2013). Given these changes, the truly distinguishing element of a resilience approach is tied to the efficacy of socio-economic factors. If it becomes apparent that these socio-economic factors do not in fact have any noticeable effect on the ability to overcome a disaster like flooding, then the added value of current existing resilience measurements would be negligible.

The prevalence of indices also appears to reflect the surprising lack of acknowledgement in resilience literature that while the goals of policy-making may be numerous, the instruments available to policy-makers to achieve these goals are limited to four categories (Howlett, 2011):

- Information (information campaigns, educational initiatives etc.)

- Legislation (making laws that regulate actors' behaviours)
- Taxation (financial (dis)incentivisation)
- Organisation (create public bodies/agencies/committees to directly provide services)

Basically, current measurement methods are wholly focussed on identifying what factors can improve resilience, without sufficiently reflecting upon whether the policy instruments needed to achieve such objectives are even available to policy-makers. It is debatable how an index, with indicators as disparate as a population's education level and building code standards, can be useful for helping policy-makers narrow down specific policy options. For instance, building code standards clearly fall under the legislative instrument category, and improving them can be done through a straightforward (relatively speaking) process of changing relevant legislature. Improving education levels however, is patently a far more complicated endeavour, that necessitates a multitude of initiatives from all of the policy instrument categories above. A policy-maker who is informed that a low resilience index score is attributable to poor building code standards has a clear pathway to improving the resilience of the area they are responsible for. If the same policy-maker is told that they need to improve the local population's education level however, then they would probably be no better off than had they not been aware of the resilience index score in the first place.

5.2.2 Recovery time as a measurement of resilience

One important issue to consider when using statistical modelling to measure resilience is choosing a suitable definition that is both amenable to measurement, and is also straightforward to monitor so that practitioners and stakeholders can easily identify whether particular initatives are having an effect or not. Having this in mind, the choice comes down to either using a strongly adaptive definition of resilience, such as Manyena et al. (2011)'s concept of "bounce forward", or a conventional "bounce back" definition. I have chosen to use "bounce back" as it is more straightforward to assess. The challenge in creating a measurement based on "bouncing forward" is that the benchmark lies not in monitoring and maintaining chosen parameters, but rather in achieving change (preferably positive). This means that in order to measure the resilience of a system, one would first need to clarify what constitutes positive change, which can be highly subjective and dependent on one's priorities. While the concept of "bounce forward" offers valuable insights, it is also unclear how to differentiate between a system that is resilient (e.g. experiencing positive change), and one that is changing to more strongly reflect a researcher's (or whoever choses the metrics) preferences. Thus, selecting "bounce forward" metrics likely involves a political decision-making process that needs to involve as many of the affected stakeholders as possible, which is beyond the scope of this study.

An interesting dilemma when attempting to measure resilience is that researchers have tended to treat the properties of "bouncing back" and "persistence" as interchangeable properties that jointly define resilience. While both terms can used to describe the capacity to overcome perturbations, there are subtle differences between them that pose significant problems when attempting to create measurements for them. Bounce-back metrics for example look at the speed at which a system can return to its original state prior to the disturbance, with quicker returns signalling better performance; whereas persistence metrics focus on the ability of a system to maintain its existing state over time, where longer time horizons signal better performance. Basically, "bounce back" emphasises speed whereas "persistence" values longevity. This has not been an issue for previous efforts to measure resilience because indexing eliminates the need to have one single measurement for resilience. In statistical modelling however, a choice needs to be made in order to enable testing of the significance of the relationship between the chosen metric for resilience, and hypothesised explanatory factors/parameters.

Since the goal of measuring resilience is to guide policy-making, whatever metric is employed needs to fulfil the criteria of being useful for informing practical policy choices. As such, it must be possible to (a) specify what is being measured, (b) decide particular points when a system is resilient and non-resilient, and (c) assess how resilient the system is at a specific time. A well-specified measurement needs to be uncomplicated, and it should be easy to identify how changes in the measurement will correspond to potential outcomes. It should also be *autonomous*, meaning it should be possible to determine how resilient a system is without relying on outside data or comparisons with other systems. This is because a measurement will only be useful if it gives information that is actionable by the target audience (i.e. policy-makers). If policy-makers are unable to act upon the information, for example because the political/legal system is too dissimilar from places where the indicators are derived from, then the measurement has not been useful for guiding policy decisions.

Given these requirements, the more suitable property to represent resilience is "bounce back" (or recovery) ability. Recovery speed is clearly the more straightforward property to measure when compared to longevity. Measuring "persistence" would require both a longitudinal study that observes the constancy of a system throughout multiple perturbations, as well as an estimation of what time-frame is relevant to be examined. It would be unreasonable to argue that a system ought to persist for a million years (to take an extreme example), since it is impossible to make reliable predictions that far into the future. By contrast, "bounce-back" can be measured using single events, with recovery speed giving a good indication of system resilience. Additionally, empirical studies have shown that slow recovery times, known as "critical slowing down", is a reliable and good indicator of decreasing resilience in natural systems (Dai et al., 2012; Scheffer et al., 2009).

Furthermore, particularly in the case of flooding, using recovery time makes it easier to determine specific points at which a system is resilient or non-resilient compared to a "persistence" metric. For example, it is not clear whether the Netherlands or Bangladesh could be said to be more capable of "persisting" during flooding. Both systems continue functioning during times of high water levels; the Netherlands through maintaining an intricate (and expensive) water management system, and Bangladesh by having infrastructure that is functional both when dry and while inundated. If the goal is simply to persist, then the Netherlands and Bangladesh are basically equally resilient, making it difficult to decide what indicators are relevant. For a "bounce back" metric - like recovery time - on the other hand, the more resilient system would be one that can recover quicker from flooding. Accordingly, any indicator that helps determine recovery speed would be considered a leading indicator of system resilience. Assessing system resilience would then be a straightforward exercise of identifying critical indicator levels that can predict significant slowing down (or speeding up) of recovery times (Biggs et al., 2009; Boettiger and Hastings, 2013; Bruneau and Reinhorn, 2007). Also, assuming that flooding will indeed become frequent due to climate change (CCC, 2015; NFRR, 2016), then recovery is also arguably a more feasible method for dealing with the inevitability of flooding than persistence. Faster recovery from flooding entails that the event passes quickly and people can carry on with their normal lives, whereas persistence (as conceptualised in resilience literature) requires people to adjust their lives to accommodate for possible extended periods of flooding. The first option is likely to be far more attractive for policy-makers who have to consider the political consequences of their decisions.

5.2.3 Survival Analysis

The most commonly used statistical modelling technique to predict the relationship between a variable of interest, and its explanatory factors/parameters is the ordinary least squares (OLS) method (Mendenhall and Sincich, 2012). However, the OLS method suffers from two drawbacks that make it unsuitable for the purposes of this study. Firstly, the variable of interest is recovery time, or in other words, the amount of time that passes until an event (flood recovery) takes place, which can be complicated to measure using OLS methods. Secondly, OLS assumes that the variable of interest (time until an event) has a normal distribution, whereas the distribution of event times are often far from normal (Allison, 2014). Given these drawbacks, a more suitable modelling method would be survival analysis. Survival analysis is a modelling technique that can be used when the variable we are interested in is time, and we wish to determine what parameters help explain the time it takes until an event occurs. OLS and survival analysis differ when modelling for time, in that an OLS model estimates how the explanatory parameters affect the *likelihood* that an event takes place at a given time, while survival analysis examines how the parameters help explain the *rate* at which an event takes place. For example, an OLS estimate will tell us whether an area with higher average educational attainment levels is more/less likely to recover from flooding at any time compared with areas with lower average educational attainment. Survival analysis estimates on the other hand, tell us if higher average educational attainment leads to faster or slower recovery times than lower average educational attainment. More importantly however, is that unlike OLS, survival analysis does not assume that the dependent variable (time) is normally distributed (Mills, 2011), which reduces the risk that the modelling will result in biased parameter estimates.

The core output of a survival analysis model is the *hazard function*. The hazard function gives the potential that the event of interest will occur at a specified time. The term *hazard function* is used mainly because survival analysis originates from the fields of engineering and medicine, where the variable of interest is usually the "failure event" (Kleinbaum and Klein, 2005), such as time until a cancer patient dies, or time until a light bulb fails. The hazard function can also represent a positive event however, such as time until a person finds employment. For the purposes of this study, the hazard function also represents a positive event (flood recovery), which is somewhat unfortunate since flooding also happens to be a natural hazard. As such, in order not to cause undue terminological confusion, the hazard function will be referred to as the "recovery function" for the remainder of this study.

Another issue to consider when using survival analysis is that the standard model tests for differences in survival times between two or more groups, which are usually divided into a control category and a treatment category (Kleinbaum and Klein, 2005). This means that in its basic application, survival analysis only allows for one explanatory variable to be included in a model, which can be anything, from gender, to a drug, or even a type of material. The survival model simply estimates if there is a statistically significant difference in survival time between the control group and the treatment group(s). A single-parameter model would not work for this study however, since the intent is to model flood recovery time against multiple explanatory factors. To account for this issue, the specific method used in this study will be the Cox regression model. Unlike standard survival analysis methods, the Cox model allows for multi-variate analysis, making it very useful for gathering information on the relationship between recovery time and a number of explanatory factors.

All the statistical modelling is done with the *R* language environment, a widely used statistical software. Techniques unique to survival analysis are handled using the “survival package”, which comes standard with the software.

5.3 Model specifications

Firstly, only inland flooding will be included in the study. This is because coastal flooding tends to be more unpredictable, since they are mainly caused by severe storm surges that have highly stochastic impacts (EA, 2009). While inland floods can also be somewhat unpredictable, there is normally sufficient time-lag between the cause (usually heavy rainfall) and the event to enable more accurate forecasting of whether flooding will actually occur. This should, at least theoretically, give practitioners and residents more opportunity to take necessary precautions (NFRR, 2016). The existence of a time-lag is particularly important because resilience is not just meant to represent the ability to react to disruptions, but also entails the capacity to act on information in order to avoid, or mitigate, events like flooding (Galaz et al., 2011). What is important in this study is finding out how much of the variability in recovery time is attributable to the indicators/parameters being studied. The greater predictability of inland flooding should theoretically make the observed variation in recovery time less influenced by underlying stochasticity than for coastal flooding, thereby allowing greater certainty in identifying whether the indicators actually do have an effect on recovery time.

5.3.1 Baseline recovery as dependent variable

The metric of resilience used in this statistical study is *flood recovery time*, as measured in number of days. Faster recovery time is equivalent to greater resilience, whereas slower recovery times indicate less resilience. In order to categorise and compare the recovery speed of various locations systematically, it is necessary to define what constitutes recovery. There are a number of ways to define when recovery has occurred, and the one that will be used in this study is *baseline disaster recovery* (NDRF, 2012). Baseline recovery is achieved when the following criteria are met:

- Infrastructure
  - Water and sanitation services restored and reliable
  - Power and utilities services restored and reliable
- Transportation
  - Roads and bridges are safe and operational
  - Public transportation services back to pre-disaster capacity
- Services
  - Government Administrations are open
  - Educational facilities are open
  - Health care can be accessed by everyone, demand returned to normal levels
- Livelihood
  - Local businesses back to normal trading

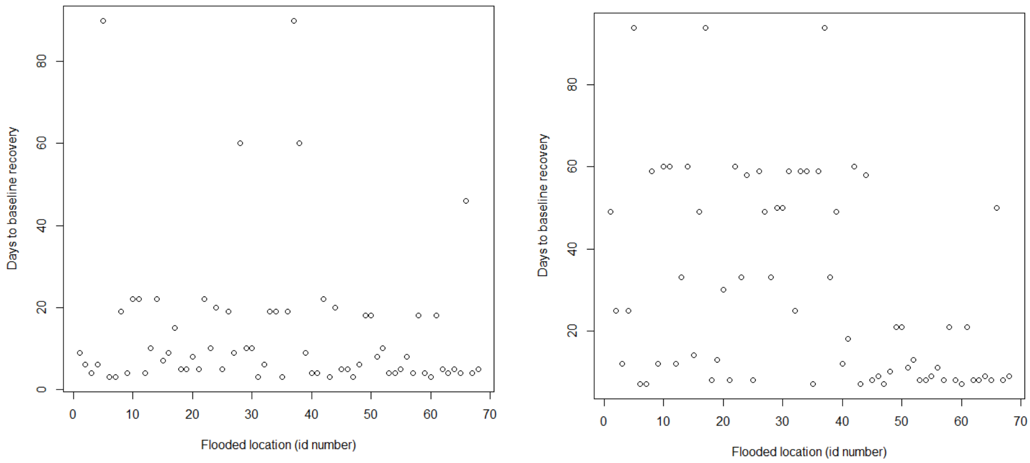
Sources: Brown et al. (2010); HMG (2013); NDRF (2012)

Choosing baseline recovery over other definitions is mostly based on measurability, and the availability of data. Some researchers have argued that resilience should encompass the ability for affected areas to go back to normal pre-disaster states (Cutter et al., 2010; Pfefferbaum et al., 2013). But it is unclear what going back to normal means in practice. If it entails a return of psychological well-being for example, then recovery may never occur if the disaster is severe enough (White et al., 2015). Not to mention that it would be extremely difficult to track the mental and emotional state of a large number of individuals consistently over an indeterminable period of time. Another possible way to define recovery time that is favoured by policy-makers and residents alike is the ability for people to move back into flooded homes (Whittle et al., 2010). Under ideal conditions, this is also likely the most suitable definition for recovery, since the ability to move back into homes would theoretically bring about a sense of "closure" for those affected, and allow everyone involved to move on from the disaster. However, in reality, the ability to move back into flooded homes is not simply attributable to FRM policies, but is also greatly determined by the particularities of the flood insurance system, and the speed at which insurance claims can be settled (Chatterton et al., 2016). It is therefore not a straightforward matter to determine recovery time using this definition, since this would involve gathering insurance claims data, which is not information that is publicly available. Nevertheless, an attempt was made to obtain insurance claims data to see if this could be included in the baseline recovery criteria for flood recovery time. However, the Association of British Insurers (ABI) does not collect disaggregated data from its members regarding filing and settling of insurance claims. Furthermore, among individual insurers, only two companies were willing to share such information. Since together, these insurers do not provide sufficient insurance coverage of all the flooded areas included in this study, insurance claims had to be excluded as a baseline recovery criterion.

It is worth noting that connected to the ability to return to flooded homes is the capacity of a locality to accommodate affected households in temporary housing and shelters. This proved not to be an issue for the locations included in this study, but this may be because the 2013/14 and 2015/16 winter floods mainly affected areas that are not very densely populated, and it was therefore a relatively minor challenge for relevant authorities to find suitable temporary accommodations when needed. The densely populated areas that were flooded - such as Bradford, Leeds, Reading, and York - did not have any households that required temporary housing. However, it is clear that the problem of temporary accommodation is likely to be an important concern for FRM practitioners, especially in densely populated areas like, for example, London. I mention this because the choice of excluding household indicators from the definition of baseline recovery is not intended to trivialise its relevance, but simply reflects the paucity of reliable and representative data on the issue. It would probably be worthwhile to include some form of housing indicator in future iterations of a statistical model, provided suitable data can be collected.

Another issue worth contemplating is when the starting point of flood recovery time should be. Since the metric of interest is recovery time, it is reasonable that measurement starts when the flood has receded and recovery initiatives have begun. However, since contingency planning includes flood response efforts during the actual flooding period, it could be argued that the starting point ought to be when flooding initially occurs. As can be seen in the chart comparison in Figure 5.1, choosing whether to include the flood period or not can potentially have a significant impact on measuring recovery time, and also how well various indicators will fit with the data.

Fig. 5.1 Plots comparing baseline flood recovery times



(a) Post-flood recovery times

(b) Recovery times incl. floods

Since including the flood period as part of recovery time requires no additional data collection efforts, both versions will be included in the statistical analysis. One model counts recovery time without including the actual flood period, meaning the start of the recovery period takes place after visible flooding has receded from the affected area, and ends when baseline recovery has taken place. The other model has recovery time starting when flooding first happens, and also ends once baseline recovery occurs.

5.3.2 Areas included in the study

The two major flood events that will be studied are the 2013/14 and 2015/16 Winter Floods. Importantly, the floods were of comparable magnitude, in terms of area affected and overall damage caused (NFRR, 2016). Both events also resulted from heavy, sustained rainfall, meaning the potential for severe floods was foreseeable (HC, 2014, 2016). Due to these similarities, both events would require similar preparation and response efforts, making direct comparisons of FRM initiatives between affected areas more pertinent. Additionally, new institutional frameworks were put in place with the Flood and Water Management Act 2010. Choosing flood events that took place after the Act came into force serves to limit any potential biases resulting from differing FRM policies. Furthermore, both flood events happened after 2011, when the most recent Census was taken. Since almost all socio-economic indicators that are used in the statistical modelling are based on Census data, having compatible information is pivotal for making a reliable statistical model.

The sampling process for choosing the locations to be included in the statistical analysis consisted of canvassing all areas that were affected by either the 2013/14 or 2015/16 Winter floods in England, by going through the Environment Agency's Historical Flood Map database. The database contains detailed records of the locations and dates for all flood events that have taken place in England since 1946, and therefore offers a comprehensive overview of areas that were affected by the two flood events. The sample was then narrowed down to include only areas that are designated as at least towns or civil parishes, with a 2011 Census population exceeding 5000. This process yielded a sample total of 68 locations, which is and exhaustive list of areas in England that were affected by either the 2013/14 or 2015/16 Winter floods that also fulfill the indicated town designation and population criteria. For each location, determining the appropriate baseline recovery time was done using the following stepwise method:

1. Analysis of LLFA Flood Investigation Reports
2. Analysis of Structured Debrief Reports from local Fire & Rescue Services
3. Incidence reports from Highways England, local bus services, and/or National Rail
4. Local news reporting

The most reliable method for collecting information on baseline recovery is by analysing Flood Investigation Reports. Section 19 of the Flood and Water Management Act 2010 requires that local authorities, in their capacity as LLFA, carry out and publish these reports in the event of flooding in their area. These reports give detailed accounts of the impact of flooding, and also list relevant actions taken by any risk management authorities involved. Flood Investigation Reports were produced for roughly half (32 of 68) of the areas affected by the two relevant flood events[1].

For the remaining locations where the LLFA did not conduct investigations, best estimates for baseline recovery were obtained by cross-referencing debriefing reports from local Fire & Rescue Services with incidence reports from Highways England, local bus services or National Rail. The Structured Debriefing Reports are intended for identifying experiences and providing practical lessons for future co-ordination of emergency response services. In

[1] Some LLFAs had multiple flooded locations within their jurisdiction, but they did not necessarily produce Flood Investigation Report for all locations

the absence of LLFA reporting, they are also serviceable documents for establishing flood recovery times since they provide a detailed timeline of incident responses. The drawback of these Structured Debrief Reports is that they only deal with emergency response activities, and therefore do not give an exact date for when baseline recovery takes place. Hence, the reports have to be cross-referenced with potential incidence reports from infrastructure providers such as Highways England, National Rail and local bus services. For locations where the Structured Debrief Reports indicated that emergency services were required, but where no other incidence reports exist, local news reporting was used as a referencing tool to ensure that flooding had not continued after emergency services withdrew. The reason why telecom, utilities, or water companies were not contacted is that, quite interestingly, both flood events had negligible impact on these services. There was therefore no need to include this information since it would not have impacted baseline recovery times.

5.3.3 The control model - modern FRM measures

To reiterate, the motivation for undertaking the statistical analysis is to find out what the added value of current resilience measurements is. As mentioned earlier in this chapter, almost all of the "soft" institutional and structural measures espoused by resilience literature already exist in modern FRM. Examples of such measures include: contingency plans, land-use planning, building codes, ecosystem monitoring and protection, early warning systems, effective communication infrastructure, insurance coverage etc. Given the significant overlap, the only truly consequential way in which resilience measurements can provide added value, is if the socio-economic indicators can help explain differences in flood recovery time better than a model or measurement exclusively made up of FRM measures. At the least, socio-economic indicators need to offer some information and insights that FRM measures do not (or cannot), in order to have contributed added value.

In order to determine the added value of current resilience measurements, it is necessary to first establish a *control model*, with FRM measures as its parameters or variables, and study how well it can explain flood recovery time. Then a *resilience model*, consisting of socio-economic indicators, will be studied and compared to the control model. The results from the individual modelling, and the comparison, is used to identify what added value a resilience approach can provide for policy practitioners. An ancillary aim of the modelling is to identify specific indicators, and potential corresponding policy choices, that can be effective for reducing flood recovery time.

Table 5.1 FRM indicators

	Indicators	Data source
Risk prevention	Management of watercourses	*Environment Agency*
	River restoration projects	*RESTORE*
	Surface water management plans (SWMP)	*LLFAs*
Flood defence	Presence of solid flood defences	*Environment Agency*
Flood mitigation	Urban green infrastructure	*LLFAs*
	Environment Agency planning objections	*Environment Agency*
Flood preparation	No. of households on early flood warning system	*Environment Agency*
	Local Resilience Forum (LRF) flood group meetings	*LRF*
	Multi-agency flood response plan (MAFP)	*LLFAs*

FRM model indicators

The indicators in the FRM model are those shared by resilience measurements and modern FRM practices, and are chosen based on the availability of data sources. These indicators will be categorised using the classification set by Hegger et al. (2013) in Figure 5.2.

Fig. 5.2 Modern FRM practices

As mentioned earlier, there was insufficient information about flood insurance since only two insurers were willing to share data, and the ABI does not collect disaggregated data. Because of this, the Flood recovery category is not included in the FRM model.

Risk Prevention

"Management of watercourses" is a binary variable, where 0= watercourse maintained by local bodies (Local Authority or IDB), and 1= watercourse maintained by Environment Agency. Watercourses are the main sources of water feeding into a town/urban area, and are therefore

important sources of potential flooding. Watercourses that are designated main rivers, such as the Thames for example, are maintained by the Environment Agency. Ordinary watercourses on the other hand are managed by other bodies such as a Local Authority or an IDB. Ordinary watercourses can be rivers, streams, drains, dikes, and any other passage through which water flows (EA, 2012).

"River restoration projects" is a binary variable, where 0= no upstream restoration projects, and 1= ongoing or completed restoration projects. River restoration is a typical example of a more integrated spatial planning approach that not only takes into consideration immediate flooding threats, but also attempts to reduce upstream contributing factors. Examples include changing from rivers from a straight flow profile to a more meandering course by rearranging river banks, and restoration of riparian vegetation. Data are collected from the RESTORE partnership's online database of ongoing and completed river restoration projects in Europe. The database is partially funded by the Environment Agency and is maintained by the River Restoration Centre (RRC).

"Surface water management plans (SWMP)" is a binary variable, where 0= no detailed SWMP in flooded area, 1= flooded area has detailed SWMP. The 2007 Pitt Review found that surface water flooding was one of the main causes of the severity of the 2007 summer floods in the UK, and recommended that all local flood authorities develop SWMPs with long-term action plans for handling the risks of surface water flooding. However, despite the critical nature of this issue, very few authorities have developed such a plan thus far (CCC, 2015). The data are collected from relevant LLFAs.

Flood defence

"Presence of solid flood defences" is a binary variable, where 0= no solid defences, and 1= presence of solid flood defences. Assets that count as solid flood defences for the purposes of this variable are: embankments, flood-gates, flood-walls, raised earth-banks, and revetments. Only flood defences protecting against river floods with a 1 per cent (1 in 100) chance of happening each year are included. Data are collected from the Environment Agency's map of Spatial Flood Defences, which not only documents the location of the defences, but also assigns relevant categories.

Flood mitigation

"Urban green infrastructure" is a binary variable, where 0= no guidance plans for Sustainable Urban Drainage System (SuDs) or Green Infrastructure, 1= has guidance plans. SuDs include permeable ground surfaces (gravel, dirt etc.), green roofs, swales etc. Green infrastructure can include green pathways along roads, canals and rail corridors. They can also be allotments, gardens and public green spaces. Local authorities that publish guidance plans for developers and planners can arguably make it easier for them to incorporate these measures in urban spaces and thereby mitigate the effects of flooding. Plans are collected from relevant LLFAs.

"Environment Agency planning objections" is a categorical variable, where 0= 10 or fewer objections, 1=11 to 30 objections, and 2= more than 30 objections. The Environment Agency is a statutory consultee for planned developments in areas at risk of flooding, and can object to development plans that do not sufficiently meet flood risk assessment requirements. The variable tallies the total number of objections for each district between 2013 to 2015. Data are collected from the Environment Agency's annual list of planning objections. It should be pointed out that number of planning objections is technically a numerical variable. The categorisation of the variable is motivated by the fact that it tends to be highly clustered, where locations either have very few objections over the relevant time period, or have in excess of 30 objections, with very few locations falling within the 11 to 30 bracket. Changing the nature of the data in this manner will undoubtedly lead to some information being lost in the conversion process, which needs to be accounted for when doing the analysis.

Flood preparation

"Number of households on early flood warning system" is a categorical variable, where 0= less than 50%, 1= 50-70%, and 2= higher than 70%. The Environment Agency provides a free flood warning service to homes and businesses located in areas at risk of flooding. The service is voluntary and those who want to sign up for the service need to create an account with the Environment Agency. Flood warnings can be issued via email, phone, or text message. The variable indicates the proportion of eligible properties in an area that are actually signed up for the service. Data are collected from the Environment Agency's internal database, which was obtained through a Freedom of Information request.

"Local Resilience Forum (LRF) flood sub-group meetings" is a categorical variable, where 0= no flood sub-group, 1= has sub-group but only meets once per year, 2= sub-group meets more than once per year. LRFs are partnerships made up of Category 1 and Category

2 responders as defined by the Civil Contingencies Act 2004. These include organisations ranging from emergency services to public utility companies. The geographical areas that LRFs cover are based on police areas, therefore the relevant police force is usually the organising body, although Fire & Rescue services can also serve in this capacity in some cases. Each LRF is constructed differently, and some have flooding sub-groups/committees specifically created to co-ordinate and plan flood response activities. Data are collected by contacting relevant LRFs, and where applicable, submitting a Freedom of Information request for meeting agendas.

"Multi-agency flood response plan (MAFP)" is a categorical variable, where 0= no local plans, 1= has either Local Flood Risk Management Plan (LFRM) or MAFP, 2= has both LFRM and MAFP. The Flood and Water Management Act 2010 requires all LLFAs to draft a Local Flood Risk Management Plan (LFRM) highlighting the local strategy for handling flood risks in their area. Meanwhile, LRFs are also encouraged to develop MAFPs detailing how they intend to provide comprehensive and sustained response to potential flooding. Having both plans could potentially indicate that the local organisations highly prioritise flooding, and therefore might be better prepared. Documents are obtained from the relevant LLFAs and LRFs.

5.3.4 The resilience model - socio-economic indicators

Since the purpose of the socio-economic model is to determine the added value of a resilience approach, the explanatory variables in the model will closely mimic those indicators that have been included in existing resilience measurements. Extrapolating from Cutter (2016); Sharifi (2016), an overwhelming majority of current resilience measurements contain the following categories of indicators: Community connectedness, educational equality, economic activity, access to healthcare, income levels, population demographics (age, ethnicity etc.), social capital. The exact metrics may differ slightly, for example some indices use doctors per 1000 residents to represent healthcare access, whereas other (primarily American) indices use percentage of population with health insurance. However, there is broad consensus and overlap between the various resilience measurements regarding the categories of indicators included in the literature.

Indicators used in this model

The most commonly recurring indicators identified in the previous section can broadly be put into four main categories: health, economic, social, and community indicators. This

Table 5.2 Socio-economic indicators

	Indicators	Data source
Health	Proportion of residents living in hospital establishments	*2011 Census*
	Proportion of population providing unpaid care	*2011 Census*
Economic	Education attainment level	*2011 Census*
	Hourly earnings	*ONS annual survey*
	Jobs densitiy	*ONS annual survey*
Social	Proportion of population giving to charity	*DMCS annual survey*
	Level of trust within the community	*ONS 2012 survey*
Community	Proportion of ethnic minorities	*2011 Census*
	Number of businesses per 1000 residents	*ONS annual survey*
	Number of voluntary organisations per 1000 residents	*NCVO report*

categorisation is used to guide selection of the socio-economic indicators that will be included in the statistical model. These can be found in Table 5.2. All the indicators are chosen based on how closely they mimic the most widely-used indicators in existing measurements of resilience. Some, such as *Education attainment level* or *Proportion of ethnic minorities* are virtually identical across the different measurements. Others, such as *Proportion of residents in hospital establishments* and *Number of businesses per 1000 residents*, are chosen because they are metrics that can represent the relevant capacities, while reflecting local data constraints. Additionally, some resilience measurements may be intended for places where economic indicators cannot be disaggregated to the same level that the Office for National Statistics (ONS) is capable of. Basically, where the indicators in Table 5.2 might diverge from those used in existing resilience measurements, the rationale for such differences is purely motivated by the quality of data available.

Health indicators

"Proportion of residents in hospital establishments" measures the number of usual residents in hospital establishments as a proportion of the total population in the district according to the 2011 Census. Residency implies longer-term arrangements, and therefore overnight stays at general hospitals or similar do not count. The definition of hospital establishment include: NHS General hospitals, NHS mental health hospitals/units, Other hospitals, Local Authority established care homes, and care homes with nursing.

"Proportion of population providing unpaid care" tracks the number of respondents who indicated that they provided at least 1 hour of unpaid care per week according to the 2011

Census. This can include for example caring for elderly, people with disability, or those with mental health issues. It does not include parental care for children.

Economic indicators

"Education attainment level" measures the proportion of the total population that has a Level 4 qualification or higher as of the 2011 Census. The ONS defines a Level 4 qualification as a post-secondary degree or equivalent. Examples include: Degree (for example BA, BSc), Higher Degree (for example MA, PhD, PGCE), NVQ Level 4-5, HNC, HND, RSA Higher Diploma, BTEC Higher level, Foundation degree (NI), or Professional qualifications (for example teaching, nursing, accountancy).

"Hourly earnings" is taken from the ONS Annual Survey of Hours and Earnings (ASHE), which is conducted in April each year to obtain information about the levels, distribution and make-up of earnings and hours worked for employees. The ASHE is based on a sample of employee jobs taken from HM Revenue & Customs PAYE records. Information on earnings and hours is obtained from employers, and the ASHE does not cover the self-employed, nor does it cover employees not paid during the reference period. Since this is an annual survey, the earnings numbers correspond to the relevant flood year, meaning if a location was flooded in 2013/14, then the 2013 figures were used.

"Job density" is the number of jobs in an area divided by the resident population aged 16-64 in that area. For example, a job density of 1.0 would mean that there is one job for every resident aged 16-64. The total number of jobs is a workplace-based measure and comprises employee jobs, self-employed, government-supported trainees and HM Forces. As with Hourly earnings, the values used correspond to the preceding year in which each location was flooded.

Social indicators

In general terms, social capital represents social connections and all the benefits they generate. Social capital is also associated with civic participation, civic-minded attitudes and values which are important for people to cooperate, such as tolerance or trust. "Social capital is the glue that holds societies together and without which there can be no economic growth or human well-being" (Grootaert, 1998). The reason why social capital is included in resilience meaxurements is that social connections that link people arguably lead them to exchange resources and form co-operative norms of behaviour. It is argued that without these networks, society would be less cohesive, and therefore less capable of dealing with unforeseen changes or disruptions (Lindley et al., 2011).

"Proportion of population giving to charity" is taken from the Department for Culture, Media & Sports' (DCMS) annual Taking Part Survey. The survey is a continuous face to face household survey of adults aged 16 and over in England. The specific question that the variable is based on is the percentage of respondents who indicated that they had donated money to a DCMS sector in the 12 months prior to being interviewed. As before, the percentages are taken from the surveys immediately preceding the relevant flood event.

"Level of trust within the community" is taken from the ONS study "Measuring National Well-being – An analysis of social capital in the UK" released in 2015. Specifically, the value included is based on "Proportion of respondents who feel that people in their neighbourhood can be trusted". Social trust, rather than other ways of measuring social capital was chosen because it is considered the most important social indicator in multiple measurements of resilience (Bergstrand et al., 2015; Leykin et al., 2013).

Community indicators

It isn't entirely clear why existing resilience measurements tend to separate community indicators from the social indicators. Most likely, social indicators are intended to be more micro/individual scale factors, whereas community level indicators are supposed to be more reflective of the collective characteristics.

"Proportion of ethnic minorities" measures the proportion of the total population in an area that self-identified as an ethnic minority in the 2011 Census. Minority groups include: Irish, Gypsy or Irish Traveller, Mixed/multiple ethnic groups, Asian/Asian British, Black/African/Caribbean/Black British, and Other.

"Number of businesses per 1000 residents" is compiled from the Inter Departmental Business Register (IDBR) recording the number of enterprises that were live at a reference date in March each year. An enterprise is generally identified using VAT and/or PAYE records, and operates either fully independently, or has a certain degree of autonomy within an enterprise group. As before, the number of businesses corresponds to the year in which the flooding occurred.

"Number of voluntary organisations per 1000 residents" is obtained from the National Council for Voluntary Organisations (NCVO) UK Civil Society Almanac for 2014/2015. Voluntary organisations can be active in the following areas: Culture and recreation, Education, Playgroups and nurseries, Research and Grant-making foundations, Health, Social services, Scout and youth groups, Environment, Village Halls, Employment and training, Law and advocacy, Umbrella bodies, International organisations, and Religious groups.

5.3.5 Similarities between resilience measurements and indices of human welfare

An important concern, that has received no mention in the literature, is that the socio-economic indicators in resilience measurements nearly completely overlap with existing indices of human welfare and well-being. For example, with the OECD Better Life Index, overlapping indicator groups include: civic engagement, community connectedness, economic activity, education, healthcare, housing, and income. While overlapping indicator groups with the English Index of Multiple Deprivations (IMD) include: economic activity, education, healthcare, housing, income, and social capital. Not only is it not self-evident that socio-economic factors should be included as metrics of resilience, it is also unclear why – given the obvious overlap – current resilience measurements have their own indicators rather than simply making use of such pre-existing indices. There appears to be little added value to incorporating a comprehensive set of socio-economic indicators, since it is doubtful that they can offer insights that cannot already be gained by looking at for example the IMD or the OECD Better Life Index.

With this in mind, it is also interesting to model flood recovery time against the IMD, as a comparison to the previous socio-economic indicator model derived from resilience literature. Considering that the IMD is already a weighted aggregate index, it is essentially a fully constructed version of a socio-economic indicators index as envisioned in resilience literature. Modelling the IMD would therefore serve as an additional means of testing the added value of socio-economic indicators for explaining flood recovery time.

The IMD was compiled in 2015, and is the official measure of relative deprivation for small areas/neighbourhoods in England. The index divides England into a total of 32,844 areas that are ranked from least to most deprived. It is also divided into ten equal sized deciles, with an area assigned to a specific decile depending on their overall deprivation rank. For example, if an area is ranked 5,000 out of 32,844, where 1 is the most deprived, then this means that the relevant area is amongst the 20 percent most deprived in the country. The index is composed of several domains, with each domain consisting of a basket of indicators that are intended to represent the general well-being of an area. The domains of the IMD are weighted in the following manner:

Income deprivation (22.5%), *Employment deprivation* (22.5%), *Education, Skills and Training deprivation* (13.5%), *Health deprivation and disabilit*y (13.5%), *Crime* (9.3%), *Barriers to housing and services* (9.3%), *Living Environment deprivation* (9.3%).

Taking into consideration how well it represents the social vulnerability aspects emphasised by resilience literature, modelling the IMD can be highly useful for determining the overall added value of a holistic, multi-hazard perspective of disaster management. If it turns out that the IMD does not explain flood recovery times for example, then this would be an indication that a holistic approach might not be useful for identifying effective FRM policy choices.

5.3.6 Level of detail of the data and related issues

One issue to keep in mind when analysing the statistical models is the level of detail of the data, particularly pertaining to spatial scale. The issue of scale is especially pertinent because a significant element of my research deals with questions about local vs. central decision-making (participatory approach) and community (community resilience and cohesiveness). Issues of scale can be problematic for statistical analysis due to the granularity of data, in that it is crucial that the data for different models is measuring the same thing. For example, using average household income for Greater London might not be at the right level of detail if we are interested in analysing questions about a specific neighbourhood or borough, since average incomes are likely to be quite different between Newham and Richmond upon Thames. A list of model parameters, along with the level of detail at which the data is collected, and be seen in Table 5.3. Looking at the table, care should be taken not to draw strong conclusions when doing a comparison between the FRM and socio-economic models since most parameters in the FRM model are at a higher level of detail (county). This does not necessarily mean that no comparisons can be made, but it does indicate that the FRM model may not be able to capture significant variables because the effects are manifested at a lower level of detail.

In terms of matching the level of detail at which the dependent variable (recovery time) is measured, the closest approximation is in the IMD model, since the selection criteria (a

Table 5.3 Data level of detail

Model	Parameter	Level of detail
FRM	Management of watercourses	County
	River restoration projects	County
	SWMPs	County
	Solid food defences	County
	Urban green infrastructure	County
	EA planning objections	District
	No. of households on early flood warning system	District
	LRF meetings	County
	Multi-agency flood response plan	County
Socio-economic	Proportion of population residing in hospitals	District
	Proportion of population providing unpaid care	District
	Education attainment level	District
	Hourly earnings	District
	Job density	District
	Proportion of population giving to charity	County
	Social capital (Level of trust)	District
	Proportion of ethnic minorities	District
	No. of businesses per 1000 residents	District
	No. of voluntary organisations per 1000 residents	County
IMD		Neighbourhood

town or civil parish, with at least 5000 residents) is at a lower granularity than both the FRM model (mostly County level) and the socio-economic model (mostly District level). The IMD is in fact at an even lower level of detail than the dependent variable since each area in the IMD is a neighbourhood[2], meaning one can potentially have multiple IMD areas. Again, this does not mean that the IMD model will be better at explaining differences in flood recovery time, or that the FRM model and socio-economic model cannot yield useful insights. It simply means that the IMD model is least likely to miss any potentially significant effects because of data having been aggregated to a higher level of detail.

[2]Defined as small areas (or neighbourhoods) in England that are classed as Lower-layer Super Output Areas, based on the 2011 Census

Chapter 6

Added-value of a holistic approach to resilience - Analysis

6.1 Introduction

The goal of the statistical analysis is to determine what potential added value a resilience approach can offer for practical policy-making in the field of FRM. The study uses *flood recovery time* as the measurement for resilience, and the subjects (individual observations) included in the statistical models consist of cities and towns in England that were flooded during either the 2013/14 Winter floods, or the 2015/16 Winter floods. There are two main models in the analysis: a *control model* (or FRM model), which has existing FRM measures as its parameters, and the *resilience model* (or socio-economic model), which has various socio-economic indicators as its parameters. The results for the models are compared to find out how well each can explain differences in flood recovery time for the flooded areas, which should provide relevant insights useful for determining the added value of a resilience approach.

An important issue to keep in mind is that interpreting the coefficients for each parameter is not entirely straightforward in survival analysis. In a survival analysis model, the coefficient denotes the ratio between two successive values of the parameter (explanatory variable), and is an expression of the proportional change in the dependent variable (flood recovery time) that can be expected with each unit change in the variable. As mentioned in the previous chapter, the core output of a standard survival analysis model is the *hazard function*, which indicates the likelihood that an event will occur at specific times. Given that the topic of analysis in my study is flooding – a natural hazard – it is important to clarify that *hazard function* in survival analysis is not used descriptively, but is simply an expression of the likelihood that an event happens at specific points in time. Keeping this in mind, the coefficients in survival analysis give information about how each parameter affects the *hazard rate* of an event (e.g. the rate – or likelihood – at which an event takes place). Coefficients with values above 1 denote an increase in hazard rate (the likelihood of an event increases), and values between 0 – 1 denote a decrease of the hazard rate (likelihood of event decreases). Counter-intuitively, for this study, coefficient values above 1 (i.e. increasing hazard rate) are a good thing because higher values indicate that the rate at which recovery takes place is increasing, meaning it is more likely that baseline recovery is achieved in a short time than a long time.

The reason for the confusing terminology is that survival analysis was originally developed in the engineering and medical fields (Allison, 2014). In these fields, survival analysis tends to be used to determine time to a failure event, such as material breakage or time of death. In these cases, prolonging the time to an event would be considered a good thing. This is not necessarily the case in other fields, such as social sciences, where shorter event timelines can be good. In order to prevent any potential confusion caused by the terminology in survival analysis, the hazard function will be referred to as the *recovery function* in this chapter. Similarly, *recovery rate* will be used instead of hazard rate.

The significance (i.e. its usefulness, or “added value”) of a statistical model is determined through hypothesis testing, which is done to establish the validity of a claim that is made about a topic of interest. This is done by assigning a p-value for each parameter coefficient, which indicates their statistical significance. Diez et al. (2015) give a more thorough overview of hypothesis-testing and the meaning of significance in statistical analysis. For the purposes of this study, the p-values essentially indicate whether each explanatory variable exerts an observable effect on flood recovery time. The lower the p-value, the more confidently we can claim that the explanatory variable has an effect on recovery time. Generally, it is assumed that p-values below the 0.05 threshold indicate a reliable level of statistical significance for the variable (Mendenhall and Sincich, 2012).

6.2 Control model - FRM measures

One detail about the FRM model that affects how the results are interpreted, is that all the parameters are either binary or categorical. This means that each parameter can only take on a limited number of fixed values. For binary (or dummy) variables, the possible values are 0 and 1, whereas categorical variables can take on more (to a limited extent) values. This is because these parameters are grouped based on qualitative properties, and have been assigned numerical values in order to enable statistical modelling. The binary variables in the FRM model are: *Critical watercourses, River restoration, Surface water plan, Green infrastructure,* and *Flood defences*. Drawing inferences from these binary variables is straightforward since the parameter coefficient estimate is a direct representation of any change in the *recovery rate* between the "control group" and the "treatment group". For categorical variables on the other hand, the same parameter may be included more than once in the model to determine how each category of the parameter differs from the baseline value. These parameters will have an accompanying number to denote which specific category is being compared to the baseline. Categorical variables in the FRM model are: *Flood warning system, LRF flood group, Multi-agency flood plan,* and *EA planning objections*.

6.2.1 Standard FRM models

As mentioned in the methods chapter earlier, I will be performing the statistical analysis using two different measurements for recovery time, which means that two regressions are used in the analysis. The first regression has recovery time measured as "time to baseline recovery, excluding the flood period". And the second regression measures recovery time as "time to baseline recovery, including the flood period". The results of running the regressions of the standard FRM model are summarised in Table 6.1. The numbers in brackets are the corresponding standard-errors of the coefficients for each parameter. Any significant (p-value) parameter coefficient is indicated by an asterisk (*), with numbers of asterisks meaning greater significance.

Looking at the results in Table 6.1, is seems that only *Flood warning system* is consistently significant (has a p-value below the 0.05 threshold) for both regressions, with *Surface water plan* and *Multi-agency flood plans* being significant for only one of the regressions. The two categories of *Flood warning system* are significant for both the "No flood period" and "With flood period" regressions, with higher sign-up proportion (category 1 is 50-70%, category 2 is >70%) in the population corresponding to faster recovery times. In the "No flood period" regression, locations with 50-70% sign-up and >70% sign-up have coefficients of 1.215 and 1.527 respectively, while in the "With flood period" regression the corresponding values are 1.988 and 2.022. A coefficient of 1.215 indicates that having 50-70% of the population signed up for the EA flood warning system leads to a 21.5% (1.215 - 1 = 0.215 = 21.5%) <u>increase</u> in the *recovery rate* compared with areas where fewer than 50% of those eligible are signed up. In practice, this means that time to baseline recovery for areas with 50-70% sign-ups is faster

Table 6.1 Estimations of FRM models

	No flood period	**With flood period**
Watercourse	0.209*	0.200*
	(0.820)	(0.827)
River restoration	0.764	1.022
	(0.391)	(0.376)
Surface plan	0.868**	1.097
	(0.304)	(0.338)
Warning system (1)	1.215***	1.988
	(0.184)	(0.184)
Warning system (2)	1.527***	2.202***
	(0.189)	(0.192)
LRF flood grp. (1)	0.496	0.480
	(0.181)	(0.191)
LRF flood grp. (2)	0.762	0.513
	(0.199)	(0.217)
Multi-agency FP (1)	2.455*	3.721***
	(0.191)	(0.199)
Multi-agency FP (2)	0.632	1.149
	(0.212)	(0.241)
Green infrastructure	0.855	1.461
	(0.395)	(0.367)
EA objections (1)	1.826*	1.464
	(0.222)	(0.216)
EA objections (2)	0.806	0.598
	(0.251)	(0.267)
Flood defences	0.961	0.907
	(0.272)	(0.326)
Observations	68	68
R^2	0.464	0.492
Likelihood ratio	42.46***	46.29***

***p<0.01, **p<0.05, *p<0.1

by 21.5%. With this in mind, the modelled results for *Flood warning system* appear to be consistent with expectations, in that higher percentages of households and businesses signed up for the EA flood warning service also correspond to faster flood recovery times.

In the case of *Surface water plan*, the estimated coefficient for the "No flood period" regression is somewhat counter-intuitive. A coefficient of 0.868 indicates that having local Surface Water Management Plans (SWMPs) would lead to a 13.2% (1 - 0.868 = 0.132 = 13.2%) decrease in the *recovery rate*, meaning time to baseline recovery for areas with

SWMPs is slower by 13.2% compared with those without SWMPs. With this in mind, it is unclear what potential inferences can be drawn from this result since the parameter is only significant for the "No flood period" regression. It is similarly difficult to draw any conclusions for *Multi-agency flood plans* since it is also only significant in one instance. However, unlike for *Surface water plan*, *Multi-agency flood plans* is borderline significant (p-value of 0.071) in the "No flood period" regression. Coupled with the fact that the coefficient estimates are eye-catchingly high, 2.455 and 3.721 respectively, it would be a highly interesting parameter to examine. The magnitude of the coefficient values is interesting because of the distinction between statistical significance and substantive significance (or effect size). Statistical significance (i.e. low p-values) is simply an indicator of whether the null hypothesis, that the parameter does *not* explain variations in the dependent variable, is true or false. Knowing the statistical significance of a parameter does not tell us whether its effect on the dependent variable is practically meaningful. This is where interpreting the substantive significance, or effect size, of a parameter becomes relevant. Analysing the potential effect size of a parameter helps determine how important the modelled results are for answering the core research question. As such, despite being borderline statistically significant, the magnitude of its coefficients necessitates further examination of *Multi-agency flood plans*, due to its potential impact on recovery time.

With this in mind, it is notable that it is the middle category of *Multi-agency flood plans* that has significant values. As mentioned in the parameter descriptions in the methods chapter, the middle category consists of flooded locations that have produced either a LFRM or a MAFP, but not both. If both categories of the parameter were significant, it would be possible to infer that having a LFRM and/or MAFP helps significantly reduce flood recovery time. However, with only the middle category being significant, it is possible that some other characteristic, shared by locations with fast recovery times, strongly coincides with the location only having one of either a LFRM or a MAFP. One possibility is that *Multi-agency flood plans* is interacting with another parameter in the model, which can affect coefficient estimates and standard errors. The ramifications of interaction effects between model variables is discussed in more detail in section 6.2.2.

Model diagnostics

In addition to finding out whether individual parameters are significant, it is also important to determine how well the overall model fits the data. For this study, the "goodness-of-fit" of a model indicates how much of the observed variation in flood recovery time that can be explained by the chosen parameters. Since the goal of the statistical analysis is to find out the added value of a resilience approach to FRM, ascertaining the goodness-of-fit of each model is important, because it allows for a direct comparison between the control (FRM) model and the resilience (socio-economic) model. If the resilience model has a better goodness-of-fit (i.e. greater explanatory power), then this would be a possible indication that a resilience approach does offer added value.

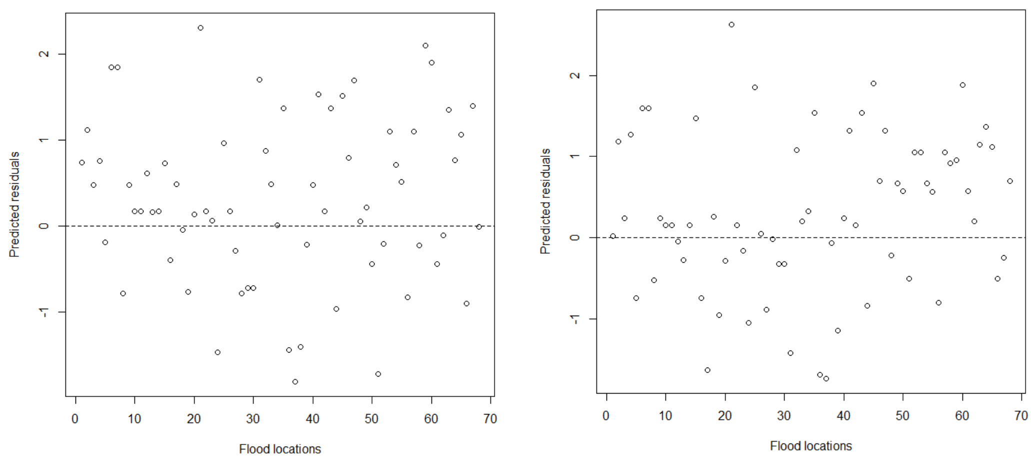
A general goodness-of-fit measure used in regression analysis is R-squared (R^2), which determines how much of the total variation in the dependent variable (flood recovery time) can be explained by the model. A more thorough discussion of the measure can be found in Diez et al. (2015). The problem with R^2 however, is that while it may be useful, it does tend to overestimate goodness-of-fit, and can be increased simply by adding more explanatory variables into the model (Mendenhall and Sincich, 2012). A better way to assess model fit in survival analysis is through a Log-likelihood ratio test (Mills, 2011). The test compares two statistical models, one being the model that is analysed, and the other is a null model. For this study, the null model simply assumes that none of the variables have an effect on flood recovery time. The Log-likelihood ratio test analyses whether a difference can be observed between the two models, and also whether this difference is statistically significant. The higher the ratio, the more likely it is that at least some of the parameters in the model can help explain the variations in observed flood recovery times. The goodness-of-fit indicators of the standard FRM model regressions can be found at the bottom of Table 6.1.

The model diagnostics indicate at least some of the parameters in the FRM model can help explain variations of flood recovery time, since both regressions are significant (p-values below 0.05) according to the Likelihood-ratio test. These variables are most likely the ones that were found to be statistically significant in Table 6.1, meaning *Flood warning system*, *Surface water plan*, and *Multi-agency flood plans*.

An additional way to assess the goodness-of-fit of a model is through residual analysis, and specifically residual plotting. A residual (e) is the difference between the observed value of the dependent variable (y), and the predicted value ($\hat{y}$), i.e. $e = y - \hat{y}$. Residual analysis is done to make sure there are no noticeable trends in how model-estimated values for recovery time differ from actual measured recovery times. Should there be any trends in the residuals, then this would be an indication that the model may be misspecified and therefore not suitable. Residual testing in survival analysis for multivariate regressions is usually done by using the "Martingale" method or the "Deviance" method. The mathematical differences between the two methods are explained in detail by (Allison, 2014). For the purposes of this study, the differences between the two methods can be summarised by the fact that “Martingale” residuals are asymmetrical. A “Martingale” residual has a maximum upper value of 1, but has no limit on its lower value (i.e. it can approach $-\infty$). To explain why they are asymmetrical, we first need to recognise that residuals in survival analysis represent the discrepancy between the actual time until a “failure” event, and the predicted time until “failure” event. Therefore, positive residual values mean that the “failure” event (for example patient death) occurred sooner than expected; whereas negative values mean that the “failure” event happened later than expected. “Martingale” residuals can therefore potentially have extremely large negative values because the “failure” event may not take place, for example because a machine part may not break down, or a cancer patient does not die.

Considering the asymmetrical nature of “Martingale” residuals, using the “Deviance” method may be more suited for this study, since all locations included in the analysis do experience the “failure” event (baseline recovery). Additionally, unlike for other studies, where longer than expected times to the “failure” event are of most interest, both positive and negative residuals are relevant for the purposes of this study. Both longer, and shorter than expected flood recovery times can offer relevant information for the analysis. As such, all residual analysis in this chapter will be done using the “Deviance” method. The residual plots for the standard FRM model regressions can be found in Figure 6.1.

Fig. 6.1 Residual plots for the FRM model regressions



(a) No flood period (b) With flood period

As can be seen, there are no observable trends in the residual plots. This means that there is unlikely to be any systematic error in the model that can lead to biased estimates of flood recovery time. The residual analysis therefore suggests that the model is generally suited for purpose, and any parameter found to be statistically significant most likely does have a valid effect on flood recovery time.

6.2.2 Model parsimony and assessing individual parameters

Another issue worth mentioning is that the regression results in Table 6.1 suggest that, since most of the parameters do not have significant p-values, they could potentially be removed without affecting the overall explanatory power of the model. One key reason for paring down the number of parameters is to achieve greater model parsimony. Model parsimony is important for correctly balancing the goodness-of-fit of a model (R^2) with the specific data used to generate said model, and the need to be able to make meaningful inferences from the model. As mentioned earlier, adding more parameters into a model will generally lead to greater goodness-of-fit. This is because the statistical model is fitted to the specific dataset used as input, irrespective of whether the results make sense. Consequently, the greater the number of explanatory variables, the likelier it is that the modelling has generated a forced-fit where the model fits the input data very well, but fails at accurately predicting outcomes for other datasets (Berk, 2004). Achieving model parsimony is therefore important for finding a model that has strong explanatory power, that is also applicable to a wider context.

Model parsimony is also important as it is one way to avoid over-specification of the model, which occurs when one or more variables are redundant. Redundant variables can lead to inflated standard errors for the parameter coefficients that can affect the overall goodness-of-fit of a model (Mendenhall and Sincich, 2012). Looking at Table 6.1, there may be an issue with over-specification as the standard errors for *Management of watercourses* appear to be disproportionate to the parameter coefficients. Furthermore, since *Flood warning system* is the only consistently significant parameter in the FRM model, it would be useful to test the significance of each explanatory variable independently to ensure that there is no forced fit at play. In survival analysis, this is done by modelling each parameter with the dependent variable separately in order to determine their model-isolated significance, which can be done using the Kaplan-Meier method.

The Kaplan-Meier method estimates the *hazard function* (recovery function) for each observation (flooded location) over time (Mills, 2011). More importantly, it can be used to calculate the recovery functions of observations under baseline conditions (null condition), and cases where an intervention (parameter) exists. These functions can then be compared using a log rank test, which yields a chi-squared value. The chi-square can be used to determine whether any differences between the recovery functions for the intervention and baseline cases are statistically significant. Higher chi-squared values correspond to greater statistical significance, and a significant chi-squared value indicates that the parameter does exert an effect on flood recovery times independently from the overall FRM model.

Table 6.2 Chi-squared values for Kaplan-Meier estimates

	No flood period	**With flood period**
Watercourse	0.911	3.201*
River restoration	0.223	0.152
Surface plan	8.341***	3.452*
Warning system	13.141***	16.145***
LRF flood grp.	0.642	1.531
Multi-agency FP	14.634***	15.421***
Green infrastructure	0.242	1.711
EA objections	4.932*	8.817**
Flood defences	1.021	2.081

***p<0.01, **p<0.05, *p<0.1

The results of Kaplan-Meier estimates for each parameter is summarised in Table 6.2. As can be seen, *Flood warning system* and *Multi-agency flood plan* are both highly significant. While *Surface water plan* and *EA planning objections* are significant for one regression, and borderline signifcant for the other. These results generally mirror the ones found from the standard FRM model regressions. With these results in mind, it would appear that the FRM model could be pared down to only include these four parameters, and not lose much goodness-of-fit and explanatory power. It is worth noting that the chi-squares for all four variables fluctuate appreciably when comparing different baseline recovery models. Coupled with the notable spread in the residual plots in Figure 6.1, this suggests that the model estimates have significant standard errors, which reduces the reliability and explanatory power of the models. The implication of the high standard errors in the FRM models, and potential ways to correct this issue, will be discussed further in the findings section.

6.2.3 Simplified FRM model

Taking into account the results from the previous section, Table 6.3 summarises a simplified FRM model using only the parameters that were found to have significant Kaplan-Meier chi-squared estimates. Looking at the model diagnostics, it does not appear that the goodness-of-fit of the model has been affected much, with both regressions having significant Log-likelihood ratios. An interesting result from the simplified FRM model regressions is that

Table 6.3 Estimations of simplified FRM model

	No flood period	**With flood period**
Surface plan	1.115	1.228
	(0.312)	(0.293)
Warning system (1)	1.230**	1.803
	(0.568)	(0.711)
Warning system (2)	1.811***	2.397***
	(0.544)	(0.781)
Multi-agency FP (1)	0.786	1.421***
	(0.211)	(0.270)
Multi-agency FP (2)	0.762***	0.754
	(0.185)	(0.179)
EA objections (1)	1.201	0.912
	(0.276)	(0.229)
EA objections (2)	1.898	1.118
	(0.298)	(0.321)
Observations	68	68
R^2	0.417	0.412
Likelihood ratio	36.73***	36.10***

***p<0.01, **p<0.05, * p<0.1

the significance of all variables apart from *Flood warning system* appears to be reduced in comparison with the standard FRM model. *Surface water plan* in particular has switched from borderline significance to practically insignificant. It is unclear why this might be the case, but the high variation of the estimates do point towards low model reliability, since higher variance also makes it more difficult to determine if a variable is significant or not. A possible explanation for these results is that there may be some interaction effects between them. Interaction occurs when the “main effect”, meaning the effect on the dependent variable (recovery time), differs from what would be expected based on the individual inputs of each explanatory variable. An oft-cited example is the effect that smoking and alcohol consumption have on throat cancer (Jaccard and Turrisi, 2003). Individuals that either smoke or drink heavily have increased risks of throat cancer. Individuals who do both are particularly at risk however, and this is because of an interactive effect between drinking and smoking. Basically, interaction indicates that the effect of one parameter on the dependent variable is different at different values of the other parameter. For this study, the possible cause of potential interaction effects may be the Local Authorities, who as LLFAs, are responsible for most of the outputs that are used as explanatory parameters in the FRM model. As such, differences in flood recovery time could potentially be better explained by which specific

LLFA is affected, than the specific FRM measures. The ramifications of a possible “Local Authority” effect will be discussed in the findings section.

Other model specification considerations

In addition to interaction effects, another issue to consider is the possibility of a confounding factor (or omitted-variable bias) of the FRM model. A confounding factor is a variable that influences both the explanatory variable and independent variable, which can result in a “biased” model since the model compensates for the missing factor by over- or underestimating the effect of one of the included factors (Allison, 2014). One potential confounding factor for the model is linked to the “Local Authority” effect mentioned previously, which is connected to the issue of spatial scale mentioned in Section 5.3.6. Most of the model parameter data are collected at the county level, whereas it is possible that a flood event affects areas within a single county unequally, thereby resulting in the model possibly omitting significant effects. For example, in chapter 4 it became clear that despite being the LLFA responsible for coordinating local FRM in North Yorkshire, meeting documents suggest that the NYCC TEEC was primarily interested in transport issues because it is of greater concern for the county as a whole. As such, decisions taken at county level may not accurately reflect circumstances at a smaller scale. Unfortunately, data for most of the parameters in the FRM model do not exist at a lower level of detail, which means that the risk of having omitted significant variables needs to be considered when presenting the findings.

Another interesting issue that was briefly touched upon in chapter 4, is the allocation of resources for FRM. A potential confounding factor could be that LLFAs that are allocated more resources also have faster recovery times because they can afford to put more attention to FRM matters. If so, then the real predictor for whether an area can recover faster from flooding would not necessarily be the effectiveness of individual initiatives, but how much resources are poured in to FRM. There is no direct statistical test for confounding variables in survival analysis. One method for verifying suspected confounding factors is to simply include the variable in the multivariate analysis and observe if it changes the p-value and standard error of the other explanatory variables (Mills, 2011). To control for the possibility that the magnitude of resources available to each LLFA is a confounding factor, I have run separate Cox regressions that includes *LLFA funding* as one of the explanatory variables. The funding metric used is Defra direct grant allocations to each LLFA for the years 2012-2013 and 2014-2015. The years were chosen because they correspond to the financial year immediately preceding each flood event (2013/14 and 2015/16), which should theoretically account for spending that has already been made rather than ongoing initiatives. While there are other funding sources available to LLFAs (notably local levies and partnership funding), these are all project-specific and are not used at the discretion of each LLFA. Defra direct grant allocations are assigned based on a start-up funding assessment (SFA) of the LLFAs needs, and serves as a general source of funding, which enables more straightforward direct comparisons. The results of including *LLFA funding* in the model can be found in Table 6.4.

Table 6.4 Estimations of LLFA funding stratification model

	No flood period	**With flood period**
LLFA funding	1.101	1.236
	(0.350)	(0.332)
Surface plan	1.215	1.128
	(0.299)	(0.313)
Warning system (1)	1.330*	1.403*
	(0.588)	(0.611)
Warning system (2)	1.711**	2.227**
	(0.644)	(0.789)
Multi-agency FP (1)	0.841	1.321**
	(0.311)	(0.369)
Multi-agency FP (2)	0.862*	0.854
	(0.195)	(0.191)
EA objections (1)	1.281	0.999
	(0.296)	(0.279)
EA objections (2)	1.608	1.518
	(0.388)	(0.402)
Observations	68	68
R^2	0.405	0.417
Likelihood ratio	35.01***	33.72***

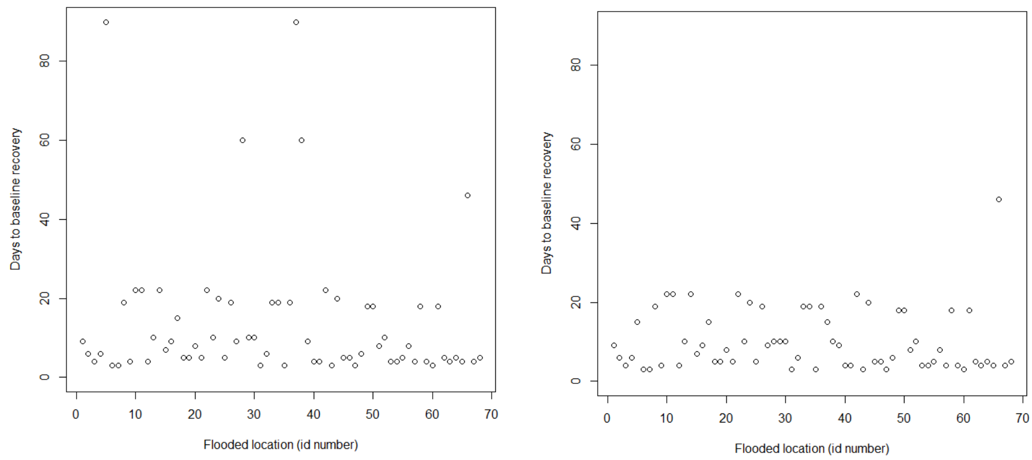
***p<0.01, **p<0.05, *p<0.1

As can be seen in Table 6.4, it does not appear that LLFA funding is a confounding factor for the FRM model, since there is no great change in the p-values and standard errors of the parameters, and the effect size of the overall model does not change noticeably, after including funding as an explanatory variable. This does not necessarily mean that there are no omitted variables in the model. It simply means that it is unlikely that LLFA funding significantly affects flood recovery times in the areas studied. Although resource allocation seems not to influence flood recovery time, it is still possible that there are omitted variables that lead to model bias, which will be considered when the findings are presented.

6.2.4 The impact of railway incidents

An interesting observation from studying flood recoveries is that rail network failures seem to have had an inordinate effect on flood recovery times for certain areas. As can be seen from the first scatter plot in Figure 6.2, failures in the rail network seem to dramatically increase flood recovery times. By discounting rail incidents from baseline recovery requirements in the second scatter plot, the variability in recovery time is smoothed out significantly.

Fig. 6.2 Plots comparing baseline recovery times



(a) With rail incidents (b) No rail incidents

Keeping in mind the potentially inordinate influence that these outlier cases can have on the general goodness-of-fit of the data, it would be worthwhile to explore what possible effect the removal of rail network repairs as a baseline recovery criterion might have on modelled parameter estimates. While it is part of critical transportation infrastructure that ought reasonably be included in any measurement of an area's capacity to recover from flooding, there is also possibly an element of luck involved. Part of the problem is that these locations were the only ones where the rail networks were exposed to flooding. It would therefore be interesting to see how robust the modelled parameter effects are, considering the possible skewness resulting from the rail network failures.

Table 6.5 summarises the results of running a regression on the full FRM model from section 6.1.1, with rail incidents discounted. The locations where the railway incidents occurred are still included in the model, their recovery times have simply been adjusted to account for the removal of rail network repairs as a baseline recovery criterion.

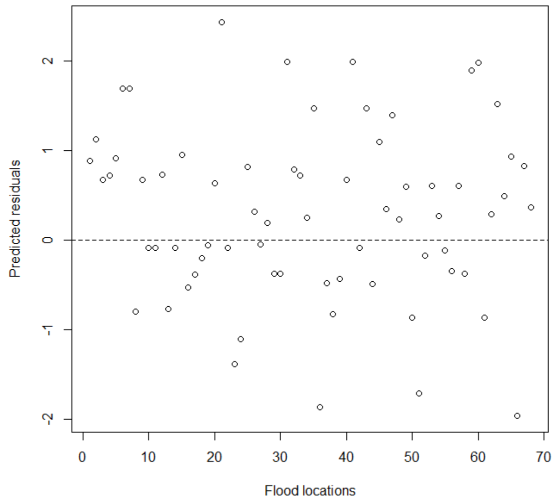
Table 6.5 Estimations of No rail incident model

	Parameter values
Watercourse	0.138
	(0.129)
River restoration	0.924
	(0.392)
Surface plan	1.491
	(0.541)
Warning system (1)	4.597***
	(0.838)
Warning system (2)	5.759***
	(0.806)
LRF flood grp. (1)	0.609
	(0.180)
LRF flood grp. (2)	0.660
	(0.190)
Multi-agency FP (1)	1.899
	(0.539)
Multi-agency FP (2)	0.573
	(0.341)
EA objections (1)	1.553
	(0.879)
EA objections (2)	0.989
	(0.511)
Flood defences	1.622
	(1.315)
Observations	68
R^2	0.514
Likelihood ratio	49.04***

***p<0.01, **p<0.05, *p<0.1

As with the previous models, *Flood warning system* is still significant, whereas *Surface water plan*, *Multi-agency FP*, and *EA planning objections* no longer have significant p-values. The results suggest that rail network failures may in fact skew the modelled effects somewhat. However, it is notable that *Flood warning system* still is highly significant, which likely indicates that its modelled effect on flood recovery times is robust. Examining the goodness-of-fit of the "No rail incident" model, the Likelihood-ratio test is significant, meaning the model has parameters that have an effect on flood recovery time. The R^2 of the model is also very similar to the other models, and the residual plot has no observable patterns. Given

Fig. 6.3 Residual plot for no rail incident model



these results, it would seem that the only useful conclusion that can be drawn is that the effect that *Flood warning system* exerts on flood recovery times is very robust, having proven to be significant in all the regressions that have been done using the FRM model. As such, it is safe to assume that the proportion of residents signed up for EA's flood warning system almost certainly helps explain flood recovery times to some extent.

6.3 "Resilience" model - socio-economic indicators

Having analysed the control model, I now turn to the resilience model. A technical detail that needs to be considered in the regression analysis is that, unlike in the FRM model, the parameters in the socio-economic model are all continuous. Therefore, the parameter coefficients in the socio-economic model do not indicate differences between a baseline group and a treatment group. Rather, the coefficients estimate how each unit change in the parameter affects the recovery rate. As is the case for the FRM model, coefficient values above 1 indicate that the parameter increases the recovery rate (speeds up recovery), while values below 1 indicate that the parameter decreases recovery rate.

6.3.1 Standard socio-economic model

Results from running regressions on the socio-economic model are summarised in Table 6.6.

Table 6.6 Estimations of socio-economic models

	No flood period	**With flood period**
Proportion residing in hospital	1.028***	1.035***
	(0.815)	(0.863)
Proportion providing unpaid care	9.846*	1.996
	(3.954)	(1.323)
Jobs density	0.324	$5.1x10^{-4}$
	(0.130)	(0.320)
Hourly earnings	1.021*	1.044**
	(0.197)	(0.232)
Educational attainment	4.283	3.050
	(0.853)	(1.052)
Proportion ethnic minority	0.707	0.001
	(0.376)	(0.108)
Proportion giving to charity	3.012	3.521
	(1.243)	(1.625)
Social trust	0.999***	0.999***
	(0.237)	(0.289)
No. of businesses	0.983**	0.985*
	(0.422)	(0.582)
No. of voluntary orgs.	4.171	0.614
	(1.582)	(0.776)
Observations	68	68
R^2	0.47	0.51
Likelihood ratio	43.42***	84.48***

***p<0.01, **p<0.05, *p<0.1

Looking at Table 6.6, only *Proportion of residents living in hospital establishments, Hourly earnings, Social trust,* and *Number of businesses* are statistically significant parameters since they all have p-values below the 0.05 threshold. While *Hourly earnings* and *Number of businesses* may both be borderline significant, it is safer to include them rather than erroneously discounting them at this stage of the analysis. Interestingly, the coefficients for these parameters reflect somewhat contradictory results. For example, the coefficients for *Social trust* in both regressions are below 1 (0.999 and 0.999 respectively). This means that, according to the regression, each unit increase in *Social trust* would lead to a 0.1% (1 - 0.999 = 0.001 = 0.1%) decrease in the recovery rate from flooding. Or more to the point, more social trust in an area corresponds to slower recovery times. This result does not make intuitive sense, and is counter to what is proposed in resilience literature. Intuitively, more social trust ought to mean more preparedness and greater capacity to deal with emergency situations, such as flooding. During the 2013/14 and 2015 winter floods however, the opposite seems to have been the case. Similarly, *Number of businesses* (0.983, 0,985) also had coefficients below 1, suggesting that more business establishments within an area corresponds to longer recovery times. Unlike for the two parameters above, *Proportion of residents living in hospital establishments* (1.028, 1.035) and *Hourly earnings* (1.021, 1.044) both have coefficient values that support the arguments made in resilience literature. Both coefficients are greater than 1, meaning they both increase the recovery rate from flooding. Intuitively, it makes sense that the higher the ratio between total residents to hospital residents in an area, the more capable it should be in coping with emergencies. Likewise, higher hourly earnings ought to mean that more resources are available for both flood mitigation and recovery measures.

There can be a number of reasons why the coefficients give contradictory results. For example, *Number of businesses* could potentially be a misleading indicator since it does not distinguish between a charity shop from a car manufacturing plant. These two businesses clearly have different impacts on local prosperity, both in terms of overall economic contributions (employment, local suppliers etc.), as well as generating more resources useful for flood recovery. Also, greater *Social trust* may lead to more willingness to help each other in times of need, but it does not necessarily mean that there is capacity to do so. *Social trust* may be indicative of a more homogeneous population, such as rural areas with older populations, in which case the greater levels of trust may be counteracted by less resources and lower capacity to cope with flooding. While the modelled effect may be small, the negative relationship between social trust and flood recovery times is of particular interest because it contradicts assumptions made in resilience literature. Expanding on the idea of population homogeneity, *Social trust* is essentially meant to measure social capital, which can arguably be interpreted as an amalgamation of social norms and networks (Woolcock, 1998). In resilience literature, it is assumed that more social capital corresponds to more shared values and goodwill, that manifests in greater community cohesiveness. The problem with assuming that shared values and community cohesiveness will lead to greater capacity to deal with perturbations, is that norms are not always conducive to positive social outcomes (Chung and Rimal, 2016). Sharing social norms and values is of little use if such norms do not lead to behaviours and actions that directly contribute to improving disaster response capacity. For example, if a community's shared norms and values lead to greater awareness and interest in the environment and natural processes, such as for example floods, then it is likely that these norms will contribute positively to flood response capacities. If sharing norms simply means that members of the community prefer playing football over rugby on the other hand, then it is doubtful that these shared values will result in greater flood response capacity.

Additionally, it needs to be mentioned that the modelled parameter coefficient for *Social trust* (0.999) is very close to 1, which means that even though it is statistically significant, its substantive significance (*effect size*) appears to be negligible. It is unclear why the modelling has returned these estimates for the parameter, but one possible explanation is that the relative intra-variable variance differs significantly for *Social trust* compared with *Flood recovery time*. The *Social trust* parameter is recorded at county level (the smallest geographical unit that the ONS maintains data for), and the highest level of social trust measured in the sample is 68.25%, whereas the lowest measured level is 65.06%. Flood recovery times in the sample on the other hand, varies from 3 days to 90 days. Extreme differences in intra-variable variance could potentially skew the parameter estimates by making them either close to 0 (as appears to be the case with *Social trust*), or make them exceptionally large. Since the relative variance in *Flood recovery time* is much greater than for *Social trust*, the parameter estimate ought reasonably have been skewed towards extremely large values (since very small changes in *Social trust* could correspond to large changes in *Flood recovery time*), but the reverse seems to have taken place. Given these issues, it is not possible to make any robust inferences about the effect of *Social trust* on recovery times. Keeping this in mind, it is still interesting that (a) the parameter estimate for social trust has the *opposite* effect on flood recovery than is assumed in the literature, and (b) the overall variation in social trust in the areas studied is minimal. Essentially, at best the modelled results suggest that *Social trust* has negligible effect on flood recovery time, and at worst they contradict the assertions made in resilience literature. The negligible effect size and unexpected coefficient value motivates a deeper analysis of the "Social trust" variable.

Alternative measurements for social capital

Given the unexpected results for "Social trust", it would be interesting to see if it might not be the most appropriate metric to represent social capital. Since the ONS has multiple measures that approximate social capital in its *Measuring national well-being – An analysis of social capital in the UK* survey, a side-by-side comparison of different metrics would be beneficial to determine the significance of the modelled results for "Social trust". The other metrics of social capital that will be used for the comparison are:

- Percentage who agreed or agreed strongly that they felt they belonged to their neighbourhood
- Percentage who volunteered more than once in the last 12 months

“Sense of belonging” is in a similar broad group of metrics as “Social trust”, and relates to individuals’ sense of place and their sentiments about *where* they live. “Volunteering” meanwhile, is more representative of the level of *activity* in an area, and assumes that higher levels of volunteering activity is indicative of greater social capital because it improves social good in an area. These three parameters are modelled separately (e.g. each parameter is the only explanatory variable included in the modelling), using the “No flood period” model, to determine which measurement is most significant, and whether the results for “Social trust” in the socio-economic model represent an outlier case. The results are presented in Table 6.7

Table 6.7 Estimations of social capital indicators

	Social trust	**Sense of belonging**	**Volunteering**
Coefficient	0.999***	1.001***	1.144*
	(0.391)	(0.462)	(0.374)
Observations	68	68	68
R^2	0.191	0.206	0.182
Likelihood ratio	19.28**	19.71**	16.13*

***p<0.01, **p<0.05,* p<0.1

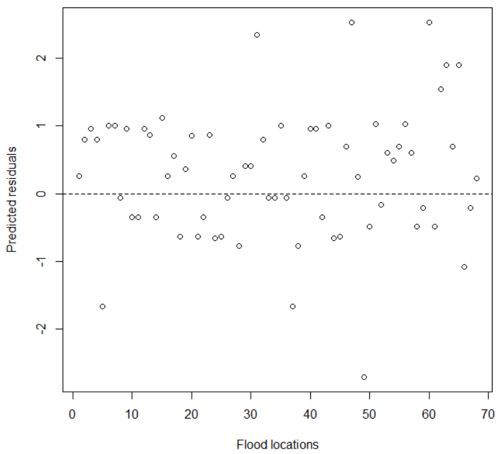
“Sense of belonging” seems to yield somewhat similar results to “Social trust”, albeit with more an expected effect (higher sense of belonging corresponding to shorter recovery time). While “Volunteering” also yields an expected parameter coefficient, although with noticeably less statistical significance (p<0.1). While these results seem to indicate that the sense of place metrics may not be best suited to represent social capital, they do not yield any definitive insights. One potential explanation for the lack of solid results could be an unsuitable level of detail of the data, in that the metrics are not sufficiently capturing the relevant effects because it is only measured at county level. This is because even though average “Social trust” could be quite high in a county, it may be significantly lower in individual areas. One possible way to account for this is to use data that represents a lower level of detail, preferably comparable to the scale at which the dependent variable is measured. This will be explored in Section 6.3.4 on the Index of Multiple Deprivations (IMD).

Model diagnostics

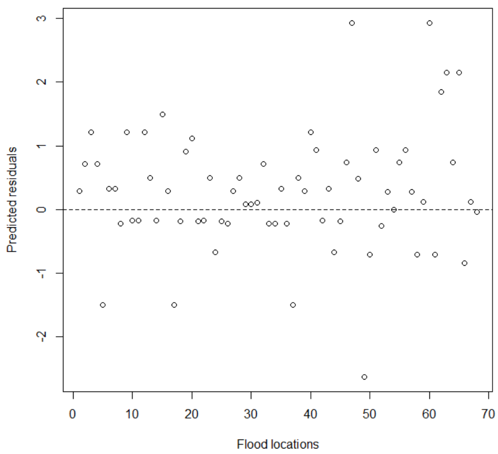
Log-likelihood ratio test results for the standard socio-economic model can be seen at the bottom of Table 6.6. The socio-economic model has very similar goodness-of-fit as the FRM model analysed in the previous section, with comparable R^2 values and Log-likelihood ratios. The one distinguishing feature being that the estimates for the “With flood period” regression of the socio-economic model has a slightly higher Log-likelihood ratio, suggesting that it may have better explanatory power than the other regressions.

Looking at the residual plots for the socio-economic model regressions in Figure 6.4, there are no observable trends in the residuals. As with the FRM model, the socio-economic model appears to be generally suited for purpose, and any parameter found to be statistically significant most likely does have a valid effect on flood recovery time.

Fig. 6.4 Residual plots for the standard socio-economic models



(a) No flood period



(b) With flood period

The initial analysis and diagnostics of the socio-economic indicator model seem to suggest that it has similar explanatory power for predicting flood recovery times as the FRM model. This suggests that a resilience approach may indeed provide some added value for practical FRM, since at least a few socio-economic indicators appear to exert an effect on flood recovery time. Most of the indicators seem to have no effect on flood recovery time however, meaning the model can probably be made more parsimonious.

6.3.2 Model parsimony and multicollinearity

As was noted in the previous section, the parameters in the socio-economic model all have continuous numerical values, which means that it is not possible to compare treatment effects against baseline values of flood recovery time. This also means that the Kaplan-Meier method cannot be used for determining the significance of each individual parameter, since the method compares the recovery functions of two or more groups. As such, for the socio-economic model, the significance of each individual parameter will instead be verified by checking for possible multicollinearity. Multicollinearity is a phenomenon in statistical modelling where two or more model parameters are correlated with each other, meaning the values for one parameter can be linearly predicted from another parameter (Mendenhall and Sincich, 2012). In practice, multicollinearity can result in coefficients that are highly variable, and lead to regressions that do not provide reliable predictions of the dependent variable. Multicollinearity could possibly explain the unusual fluctuations in the coefficients for *Number of businesses* observed in the standard socio-economic model regressions. The consequence of multicollinearity is that it can affect the overall significance of the model, making it difficult to draw useful inferences.

Furthermore, as with the FRM models, the socio-economic models can also potentially be over-specified, which is another motivating factor for testing for multicollinearity and ensuring model parsimony. The socio-economic model used in this study is based on a list of the most commonly used metrics (as referenced in (Cutter, 2016; Sharifi, 2016)), and therefore represents current theoretical research fairly comprehensively. However, considering that some existing measurements of resilience include over 70 indicators, it is quite likely that some over-specification has taken place - something that has already been pointed out by for example (Burton, 2015). Testing for model parsimony is therefore also a way to ensure that the analysis is robust.

One method of testing for multicollinearity is to construct a Pearson's correlation matrix, which describes the bivariate relationship between individual parameters, and indicates whether their correlation can be attributed to the randomness of the data. The matrix summarises the Pearson's correlation coefficients between all parameters. The Pearson's coefficient is a measure of the strength of the association between the two variables, and can take on any value between -1 to 1. A value of -1 means that the two variables are perfectly negatively correlated, while 1 means that the variables are perfectly positively correlated. Perfect correlation means that each unit change in one variable results in a commensurate change in the other. If multiple parameters have significant Pearson's coefficients, then this would be strong evidence of multicollinearity in the model. A Pearson's correlation matrix of the socio-economic model parameters can be found in Table 6.8.

As can be seen in Table 6.8, most of the explanatory factors are highly correlated with each other, indicating that it is possible to pare down the number of indicators significantly. More importantly, of the four variables found to be significant in the earlier regressions,

Table 6.8 Pearson correlation matrix for socio-economic indicators

	unpaid care	**job density**	**hour earn.**	**education**	**ethnicity**	**charity**	**soc. trust**	**business**	**vol. org**
res. hosp.	-0.5123	0.2133	-0.0266	0.0291	0.4329	-0.2306	-0.1475	-0.2395	-0.1995
	(0.000)	*(0.081)*	*(0.829)*	*(0.814)*	*(0.000)*	*(0.059)*	*(0.230)*	*(0.049)*	*(0.103)*
unpaid care		-0.4556	-0.6349	-0.6392	-0.5783	-0.1713	-0.3711	-0.2664	-0.1066
		(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.152)*	*(0.002)*	*(0.028)*	*(0.387)*
job density			0.5394	0.7785	-0.1954	0.3336	0.5059	0.7271	0.2473
			(0.000)	*(0.000)*	*(0.110)*	*(0.005)*	*(0.000)*	*(0.000)*	*(0.042)*
hour earn.				0.8075	0.1386	0.5933	0.6692	0.7175	0.4070
				(0.000)	*(0.523)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
education					0.0789	0.4909	0.7164	0.7954	0.3931
					(0.523)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.001)*
ethnicity						-0.2614	-0.0429	-0.2733	-0.2622
						(0.031)	*(0.728)*	*(0.024)*	*(0.031)*
charity							0.8007	0.5436	0.9029
							(0.000)	*(0.000)*	*(0.000)*
soc. trust								0.5917	0.6743
								(0.000)	*(0.000)*
business									0.4531
									(0.000)

Note: In the Pearson matrix, a low p-value (0.05 or below) indicates that the correlation is significant, meaning the variables are likely to be strongly correlated.

only *Proportion of residents living in hospital establishments* is not significantly correlated with the other variables. This puts into doubt how reliable the observed significance of *Hourly earnings, Social trust*, and *Number of businesses* actually are. Furthermore, since the socio-economic indicators have been chosen because they closely mimic those found in current resilience measurements, these results seem to suggest that there are high degrees of redundancy in these measurements. This puts in further doubt the potential added value of current resilience measurements for informing policy choices.

Due to the high degree of correlation, it would appear that a simplified socio-economic model is needed to assess whether the remaining variables remain significant after adjusting for multicollinearity. Since three of the four variables that are significant in the earlier regressions are highly correlated, the most appropriate choices for the simplified model would appear to be *Proportion of residents living in hospital establishments* and *Social trust*. The latter is chosen over *Hourly earnings* and *Number of businesses* because it is the most consistently significant variable of the three.

6.3.3 Simplified socio-economic model

The most important information from Table 6.9 is that both *Proportion of residents living in hospital establishments* and *Social trust* remain significant in both regressions of the simplified model. This seems to suggest that they were correctly chosen, and that most

Table 6.9 Estimations of simplified socio-economic models

	No flood period	**With flood period**
Proportion residing in hospital	1.014***	1.126**
	(0.362)	(0.327)
Social trust	0.999***	0.999***
	(0.391)	(0.399)
Observations	68	68
R^2	0.331	0.546
Likelihood ratio	27.28***	53.71***

***p<0.01, **p<0.05,* p<0.1

socio-economic indicators in existing resilience measurements do not help explain variations in flood recovery time. However, given the issues surrounding *Social trust* discussed in section 6.3.1, it is difficult to draw any substantive inferences about it despite the parameter's statistical significance. A second result worth mentioning is that the "No flood period" and "With flood period" regressions have quite different goodness-of-fit (Log-likelihood ratios of 27.28 and 53.71 respectively) in the simplified model. Also, it is somewhat surprising that the simplified "With flood period" regression has a higher R^2 than its "full" counterpart. Generally speaking, goodness-of-fit tends to decrease with fewer parameters, but this is clearly not the case for the simplified "With flood period" regression. What this implies isn't entirely clear, but it would appear that both parameters are strongly related to the length of time that a place is inundated in some way. This does not mean that high proportions of hospital residency and greater levels of social trust lead to lengthier flooding. It simply means that some characteristics shared by locations with higher proportions of hospital residents and social trust, make them coincide with longer inundation periods. It is not within the scope of this study to theorise on what such characteristics could possibly be, but it is certainly an interesting line of query for future research.

6.3.4 Index of Multiple Deprivations (IMD) model

The findings from the previous section put into focus the debatable added value of existing resilience measurements. I have already noted in the methods chapter that there is substantial overlap between the socio-economic indicators in resilience measurements, and existing indices such as the OECD Better Life Index and the English Index of Multiple Deprivations (IMD). Given the equivocal results for the socio-economic model, it would be interesting to see if a measure such as the IMD might do better for predicting flood recovery times. Additionally, the IMD is also a potentially useful measurement to account for the level of detail issues mentioned in the previous section as well as in chapter 5. Because the IMD is measured at neighbourhood level, using it should also offset the issue of a mismatch in spatial scale between the dependent variable and the explanatory variables.

Since the IMD is already a weighted index, it has to be treated as an ordinal variable (data that have natural ordered categories) for regression analysis purposes. The IMD model will therefore be very similar to the FRM model in that the coefficients are comparisons of each level of the parameter to a baseline value. For the IMD model, the baseline value is 1, meaning the 10% least deprived areas. The model then compares each subsequent level of the IMD to be baseline value, and determines if there is a statistically significant difference in flood recovery time between them. If a statistically significant difference is found, then as with the FRM model, the coefficient indicates the ratio of the recovery rate between the relevant level and the baseline. For example, a coefficient of 1.361 (for the Tenth decile in the "No flood period" model) means that an area that is among the 10% most deprived in England would have a 36.1% higher recovery rate, thereby experiencing a faster recovery time, than an area among the 10% least deprived. The results for IMD model regressions, and their corresponding model diagnostics can be found in Table 6.10.

Based on the regression results, it appears that the deprivation level of an area does not have a significant effect on flood recovery times. The coefficient values are not significant, the explanatory power is low, and neither regression passes the Likelihood-ratio test. These results mirror those of the earlier regressions to a degree in that most socio-economic indicators seem not to have a noticeable effect on recovery time. The main difference between the IMD and the socio-economic model, is that the statistical significance of the latter can largely be attributed to two individual factors, *Proportion of residents living in hospital establishments* and *Social trust*. Since the IMD is a weighted aggregate, the regression models would not be able to pick up potentially significant individual variables. These results should not be over-interpreted; however, they do raise relevant questions regarding what potential added value social-economic factors actually offer for informing FRM policies. While getting a comprehensive and holistic overview may be important for understanding complex phenomena, it is fair to ask how useful current methods of using comprehensive indices are for identifying specific policy actions that need to be taken. These issues are discussed further in the findings section.

Table 6.10 Estimations of IMD model

	No flood period	**With flood period**
Second decile	0.379	1.157
	(0.115)	(0.163)
Third decile	0.724	0.866
	(0.549)	(0.523)
Fourth decile	0.937	1.065
	(0.310)	(0.320)
Fifth decile	1.179	1.494
	(0.719)	(0.732)
Sixth decile	0.685	0.682
	(0.358)	(0.352)
Seventh decile	1.268	1.487
	(0.637)	(0.708)
Eighth decile	0.902	1.432
	(0.625)	(0.701)
Ninth decile	3.426	5.801
	(1.237)	(1.829)
Tenth decile	1.361	3.265
	(1.222)	(1.582)
Observations	68	68
R^2	0.146	0.149
Likelihood ratio	10.72	11.63

***p<0.01, **p<0.05, *p<0.1

6.4 Findings

6.4.1 Findings for core questions

Findings from the statistical modelling should be considered bearing in mind the issues surrounding the level of detail of the data that have been mentioned throughout the analysis. As has been mentioned, data for the FRM model are mainly collected at County level, while data for the socio-economic model are mostly at District level. Neither model has data that consistently matches with the level of detail of the dependent variable, which is at town/civil parish level. The difference in granularity could potentially have resulted in some significant effects being lost due to the data being aggregated. With this in mind, the statistical modelling suggests that that there is equivocal evidence for the added value of a resilience approach to policy formulation in the field of FRM. The *resilience model* consisting of socio-economic indicators does not noticeably explain variations in flood recovery time better than the *control model* of FRM measures. *Proportion of residents living in hospital* *establishments* and *Social trust* are the only variables in the socio-economic model that have consistently significant effects on flood recovery time. These two variables alone accounted for most of the socio-economic model's overall explanatory power (R^2). The FRM model had similar results, where only *Flood warning system*, and to a limited extent *Multi-agency flood plan*, are the consistently significant variables across all iterations of the model. These results suggest that there are socio-economic factors that can offer new insights for practical policy-making; however, the holistic approach espoused in resilience literature is unlikely to be very useful.

The holistic approach to resilience is motivated by the belief that the interactions between natural disasters and societies are too complex to be manageable through targeted policy solutions. While the premise that societies are complex systems is reasonable, the insistence on espousing holistic methods is less so. What seems to be forgotten is that while there may be countless overlapping and interlinking relationships within a social system, not all of them will be equally relevant for specific problems that need to be solved. Even in systems dominated by interconnectedness, there are still variables (leading indicators) that signal future events, while others are simply background "white noise". Furthermore, there is a general tendency in current methods of measuring resilience to assume that the value of incorporating "social vulnerability", through the use of various socio-economic indicators, is self-evident. The result has been that there is little justification and evidence for <u>why</u> such indicators are important for resilience. An example is the case of social capital, which is widely assumed to have a positive effect on resilience in the literature. However, modelling in this study has yielded equivocal results, where the effect of social capital on flood recovery time may depend on how the concept is defined for example. Additionally, as seen in the comparison between the socio-economic model and the IMD model, using different methods to measure social capital and collecting data at different scales can also impact findings. While there may be room to debate whether "recovery time" is the best metric for resilience, it is clear that much work still remains to ensure that there is also empirical support for any factor that is theorised to enhance resilience.

At the core of the "added-value" question is that it should be possible to logically connect decision parameters to policy objectives, in that they are supported by empirical evidence and also make practical sense. A socio-economic indicator such as *Jobs density* is a good example to illustrate the matter concerning parameters needing to make practical sense. Does it truly follow logically that in order to increase flood resilience, the Government should implement policies that create more jobs? It is most likely correct that economically deprived areas are less able to cope with the consequences of flooding than more affluent areas, and therefore the issue is at least tangentially related to FRM. But is economic equality better addressed through FRM policies, or fiscal policies? Simply put, in trying to make the property holistic, current resilience research seems to have put little consideration to ensuring that the tools match the task.

A more effective approach for dealing with complexity and uncertainty is then to be more specific rather than general when defining resilience. It would not be far-fetched to assume that many of the economic, health, and social phenomena identified in resilience literature are in fact manifestations of the same root issues. As such, in order to provide better information for policy decisions, a more effective approach would be to focus efforts on identifying the most relevant factors rather than incorporating as many as possible. By specifying, and limiting, what is meant by resilience, it becomes easier to identify pertinent factors that influence it. Specificity does not mean oversimplifying however. Oversimplification implies insufficient understanding of the relationships between various factors, which is what resilience literature criticises traditional command-and-control policies of doing. Specificity on the other hand, means that the objectives of interventions are clearly stated and understood, which does not preclude acknowledging the complexity of potential tasks. Defining resilience as a specific – rather than general – property makes it easier to connect decision parameters to policy objectives, which in turn will help narrow down the specific instruments needed to effectively manage flood resilience.

One method for achieving greater specificity of resilience is to identify the pertinent factors that are useful for achieving a policy objective through statistical modelling, as has been done in this study. Despite the overall FRM and socio-economic models being insignificant, several individual parameters can potentially be highly useful. *Flood warning system* and *Multi-agency flood plan* for example can provide important insights for practitioners. It is clear that a higher proportion of residents signed up for the EA's flood warning system corresponds strongly to faster flood recovery times, and having a Multi-agency Flood Plan also seems to help explain faster recovery times. This information offers practitioners very practicable policy choices that can also be effective. Furthermore, while they may not offer directly practicable policy options, the results for *Proportion of residents living in hospital establishments* and *Social trust* can still provide practitioners with useful information on particular directions worth exploring in search of more effective FRM policies. Basically, statistical analysis is a useful method for improving the potential added value of resilience by making it an evidence-based concept.

6.4.2 Limits of the model

As has been mentioned, quality of data may be a limiting factor on the inferences that can be drawn from the modelling. One potential explanation for the low significance and high standard errors could be that the metrics being used are insufficiently targeted to the relevant scale (Frazier et al., 2013). Some socio-economic indicators for example, are only available at county level, which means that potential variations between locations within the same county would be lost. Similarly, because FRM in the UK is an amalgam of different actors with responsibilities across varying geographical scales, it can be difficult to isolate the influence of local versus regional/national factors. One method to account for scalar factors as a next step for statistical analysis of resilience is to use multi-level modelling. Multi-level models recognise that variables may be hierarchical, or clustered, and outcomes can therefore be due to individual factors or cluster attributes (Snijders and Bosker, 2012). For instance, even though many LLFAs have drafted LFRM strategies as required, there may be county-level attributes that render these documents more or less effective, the so-called "local authority" effect hypothesised in section 6.2.3. These attributes are not necessarily socio-economic factors, but can instead be political tradition, managerial know-how, or other attributes that are not immediately apparent when looking strictly at the socio-economic and FRM indicators used in the statistical analysis earlier. Separating these cluster attributes could potentially make it easier to identify the efficacy of individual measures, thereby helping to narrow down policy choices.

Another limit of the statistical models is that while I would argue that recovery speed is the best available metric for resilience, it is also an imperfect one. Faster recovery speeds do not automatically entail greater capacity to cope with flooding, or even better outcomes (Platt et al., 2015). For example, if there is a rush to get transportation infrastructure back to normal after a flood, which results in sub-par repairs of roads that lead to a higher frequency of traffic accidents, then it would be difficult to claim that the system exhibits resilience. As such, using recovery time as a metric for resilience clearly requires speed to be balanced against other criteria, such as well-being, social utility, and economic costs. But despite the challenges in finding the appropriate specifications, if the goal is to use resilience to inform policy-making, then defining it as a specific property, such as recovery speed, is still preferable to the general definition currently being used. This is because while recovery speed may need fine-tuning in order to be a practicable measurement of resilience, analysing its relationship with various variables still enables policy-makers to pinpoint particular instruments that can be effective.

6.4.3 Other findings

Perhaps the main issue affecting the statistical modelling is the difficulty in obtaining quality data, especially for variables in the FRM model. Determining baseline recovery time was quite challenging for example, since half of the affected LLFAs had not produced Flood Investigation Reports for the two flood events in the study, as is their statutory obligation. Likewise, this lack of data and information also greatly affected the type of data that could be included in the FRM model.

One crucial variable that was originally meant to be included in the FRM model is the proportion of properties in an area that had undertaken wet-proofing, or flood-proofing, work prior to the relevant flood events. Retrofitting is one of the most widely used measures in the "flood mitigation" category, and is one of the core agenda objectives identified in the 2016 National Flood Resilience Review. Neither local councils or the Environment Agency maintains any records of property retrofitting in flood risk areas. Insurers do have information on properties that have done so for insurance underwriting purposes, but these do not cover all properties at risk, only those that have already done retrofitting. Also, insurers are not very forthcoming with their data since it is of commercial interest. The only potentially useful source of information is the "Property Flood Resilience Database" currently being developed by Innovate UK and Building Research Establishment (BRE) Group in partnership with Axa and Lexis Nexis. But it is unclear how comprehensive this database will be, or whether it can offer enough detail about property retrofitting in order to accurately capture its effect on flood recovery.

The paucity of data is arguably simply a manifestation of underlying issues such as unclear responsibilities, and limited awareness of actors' roles that afflicts British FRM (Bosher, 2014). One issue that noticeably affected flood recovery time is whether the source of flooding was fluvial, or whether it resulted from groundwater and surface water saturation. Those locations where the cause of flooding was primarily fluvial all had shorter recovery times than places where the primary cause was groundwater or surface water. This is somewhat surprising since the risks of ground and surface water flooding are well known. In fact, the Pitt Review of the summer floods in 2007 identified surface water as one of the most important issues that needed to be addressed. Judging from the information obtained while gathering data for the statistical models, it appears that the recommendations from the Pitt Review have gone largely unheeded. There are probably numerous reasons why little has been done about surface water management, but unclear responsibilities as well as potential lack of capacity from local actors to carry out their roles, appear to be notable causes.

Chapter 7

Conclusion

The core research question of this study has been to ascertain what new insights the concept of "resilience" can offer policy-makers operating in a practical policy setting, by using flood risk management as an example. I have explored this question by analysing the potential added value of two facets of resilience that constitute its main theorised contributions to policy-making. The first of these is the procedural aspect of resilience, consisting of a learning component and a participation component, which are meant to improve how policies are formulated. The second is the evidential aspect of resilience, which consists of the information (i.e. data, reports etc.) used by practitioners to help them better understand problems, and justify why particular policies are needed.

Summary of findings

In chapter 3, I studied learning and experimentation. In SES literature, learning is a highly deliberate process of recursion that eventually leads to adaptation. The objective of learning, as defined in resilience literature, is to acquire knowledge, which is then used to change policies and help improve the capacity of a system to adapt to disruptions. This conceptualisation essentially understands adaptation as synonymous with policy change. This "experimental" framework implies that policy-making is a rational process, where policy changes are only made when taking into consideration relevant inputs from changing conditions. Given that the recursive, experimental, approach to learning is highly idealised, there is a conspicuous lack of empirical studies on how a recursive learning process might be carried out in practice. With these issues in mind, the goal of the chapter was to determine if learning, as conceptualised in SES literature, is feasible in a practical policy context. This was done by conducting case studies of two Defra-funded experimental FRM pilot projects located on the Holnicote Estate and in Pickering Beck. The case studies were carried out by performing preliminary desk studies of relevant project documents, and then I conducted interviews with relevant policy managers and practitioners, focussing specifically on identifying how learning comes about in a practical policy setting.

Findings from studying both the Holnicote and Pickering pilot projects suggest that learning in a practical policy context bears little resemblance to the rational, experimental process envisioned in resilience literature. While experimental projects can indeed lead to knowledge acquisition and stakeholder learning, it is unclear to what extent they engender wide-spread policy change. The case studies suggest that rather than being an open-ended, evolving process, learning in practice is strongly influenced by stakeholders' motivations and organisational objectives. In particular, knowledge acquisition and learning from participants of these experimental projects may not necessarily lead to successful knowledge transfer to other parties, or result in policy change. The findings specifically point towards money (i.e. Government funding) being an important factor for both limiting and motivating/driving policy change. Furthermore, political influences and outside factors (such as the media or new legislation) are substantially more important drivers of policy change than is acknowledged in SES literature. Based on the results of studying the Holnicote and Pickering pilot projects, it would appear that a policy process whereby policies are made through recursive learning and experimentation may be too idealised to be feasible in a practical policy setting.

Chapter 4 focussed on the practicability of participatory methods. The main argument for greater participation is that it leads to better information-sharing and enables knowledge acquisition by fostering "social learning". It is asserted that a participatory approach allows greater diversity of problem perception, and empowers local communities so that they do not become dependent on government interventions. These changes result in greater resilience by increasing the variety of potential solutions for dealing with uncertainty, and by inducing behavioural changes that lead to greater self-reliance. However, participation is often defined in vague terms, with overly simplistic conceptualisations of the relationship between "local communities" and central authorities. Despite widespread agreement that participatory decision-making enhances resilience, some important questions remain unanswered, including: (a) Are stakeholders able to freely engage in information sharing that leads to policy decisions?, and (b), do participatory methods necessarily lead to a greater range of problem perception? These issues were studied using a two-pronged approach, focussing on participatory bodies engaged in FRM in the area around Pickering. The first section was carried out through desk studies of meeting documents of the local participatory bodies to ascertain any potential political or contextual constraints. The second section consisted of a survey questionnaire sent to local residents around Pickering, used to examine the views and representativeness of local stakeholders that are likely to participate in these local bodies.

The main finding from chapter 4 is that the use of participatory methods is not a “magic bullet” that can provide diverse interpretations, and informed arguments useful for solving complex problems. Participatory methods do seem to confer clarification, and sometimes even change participants’ views, by increasing awareness of complex issues. The participatory bodies that were studied can be highly effective at collating information and exchanging ideas when used in a strictly deliberative capacity, but the political and institutional context in which these participatory bodies exist have significant influence on policy decisions. Basically, it is possible that the role of a participatory body can be shaped as much by the policy context in which it exists, as by its participants, or even its original intended purpose. Additionally, it is likely that in order to make participatory bodies truly representative, it is important to clearly designate who assumes the political accountability of decisions. This is important because the findings suggest that local participatory bodies risk having participants who are “usual suspects” with political views that may differ from the rest of the local population. Without clearly specified protocols and guidelines for the functioning of a participatory body, it risks becoming a means to circumvent the normal democratic process since those who might disagree with their decisions would have minimal means of holding the participants accountable, the way that they could of elected public officials.

In Chapter 5 and 6, I shift focus to the evidential aspect of resilience, by studying how the concept is measured. The issue of substance, or information, is important because in order to make better (i.e. more effective) policies, it is important that the information being used is relevant for the task at hand, and gives policy-makers a better understanding of the underlying issues that are being addressed. There is general agreement in the literature that resilience is a difficult concept to measure, but I would argue that this is because current methods for measuring resilience all define it as a multi-hazard property, meant to represent a capacity to deal with any contingencies that may occur. By making resilience a multi-hazard property, it becomes necessary to incorporate a wide range of variables that may be either unrelated, or only cursorily related to the task facing policy-makers. With this in mind, it is pertinent to question whether the measurement difficulties are in fact a problem derived from the manner in which resilience is currently conceptualised. It appears that existing literature conflates a “holistic approach” with imprecision and ambiguity, which has resulted in vague definitions of resilience that can offer little clarity for policy-makers faced with specific problems. Keeping in mind these issues, I explore the added value of existing resilience measurements by examining the relevance of socio-economic resilience indicators for predicting flood recovery times of areas in England that were affected by the 2013/14 and 2015/16 Winter floods. I do this using survival analysis (a form of statistical modelling) to compare the efficacy of a socio-economic indicator model to a control model consisting of various modern FRM policy measures.

The statistal modelling suggests that there is equivocal evidence for the added value of a multi-hazard resilience approach when applied to the field of FRM. The socio-economic indicator model, which incorporates the most widely used indicators in existing measurements of resilience, does not noticeably explain variations in flood recovery time better than the control model consisting of modern FRM measures. While the results indicate that there are individual socio-economic factors that can affect flood recovery time, a majority of the socio-economic indicators proved insignificant. These results suggest that the current, holistic, approach to measuring resilience is probably severely over-specifying the number of variables that impact flood recovery times. This in turn indicates that if the objective is simply to improve FRM policies, then it is likely more beneficial to have a narrower - and more specific - definition of resilience than the current multi-hazard approach.

Some limiting factors that could potentially affect the findings from the statistical analysis include firstly the issue of scale. As was mentioned in both chapter 5 and 6, the FRM model and socio-economic model generally have parameters that are measured at different spatial scales (county vs. district). Both models also differ in scale from the dependent variable, which is measured at town/civil parish scale. The discrepancy in detail could potentially lead to a failure to identify significant effects. Additionally, the results from the statistical model suggest that a multi-hazard approach to resilience does not appear to be effective in predicting flood recovery time. However, there is room to debate whether "recovery time" is the most suitable metric to represent resilience, as many scholars would argue that adaptation and "bounce forward" better conceptualise resilience to natural hazards such as flooding. As such, it is possible that a multi-hazard concept of resilience can have more significant modelled effects on "bounce forward". This would require finding a suitable way to measure "bounce forward", which as has been mentioned in chapter 5, is far from a straightforward task.

A final limiting factor on the inferences that could be drawn from the statistical modelling is that the quality of data available was sometimes inferior, with inconsistencies in flood incidence reporting between various local authorities being one of the main problems. Despite the responsibilities of the local authorities - as Lead Local Flood Authorities (LLFAs) - being made quite clear in the Flood and Water Management Act 2010, there was considerable variation in the extent to which they had carried out such duties. One potential method that can be used in future research to deal with variable data quality and other limiting factors resulting from differences between local authorites, is to use multi-level modelling. Multi-level modelling allows hierarchical and clustered effects (such as managerial or political differences between local authorities for example) to be isolated from other model paramenters, thereby making it more straightforward to identify the efficacy of individual indicators, which would be more useful for narrowing down policy choices.

With the above issues in mind, a more effective approach for dealing with complexity and uncertainty is then to be more specific rather than general when defining resilience. In order to provide better information for policy decisions, a more effective approach would be to focus efforts on identifying the most relevant factors rather than incorporating as many as possible. By specifying, and limiting, what is meant by resilience, it becomes easier to identify pertinent factors that influence it. Defining resilience as a specific – rather than general – property makes it easier to connect decision parameters to policy objectives, which in turn will help narrow down the specific instruments needed to effectively manage flood resilience.

Concluding remarks

Batabyal (1998) noted early on that resilience was “too vague a concept” to offer concrete methods and tools for analysing social systems, and it seems that his observation is still largely valid today. The rapid expansion and popularisation of the concept seems to have inadvertently turned the term *resilience* into a political Rorschach test, in that *resilience* can be what one wants it to be. Currently, it is at once: a conceptual framework for thinking about society as a system, a tool for advancing social justice and citizen empowerment, a mechanism for promoting sustainable resource use, and much more. Its malleability risks making resilience into a buzz-word, that can be presented as an identikit solution to any problem, regardless of its nature. It is interesting that resilience is widely touted as a suitable concept to be employed for dealing with climate change. The issue of climate change is indeed representative of complexity, with various factors and feedback mechanisms that make it hard to predict its gravity, and how it will impact societies. But it is quite clear that unsustainable levels of greenhouse gas (GHG) emissions are the driver of this change. As a result, it is also quite straightforward that the overall objective of any policy intended to tackle climate change should be to reduce or eliminate GHG emissions. There is currently no such clarity for policies to enhance resilience. What is the objective of resilience, other than being resilient? Is it economic development to increase capacity? Educational reform? Increasing the effectiveness and affordability of public health? The answer currently seems to be: do everything. As well-meaning as the intentions are, this is not useful input for informing policies.

I would argue that current conceptualisations of resilience have simply committed the classic design error of approaching a problem in the middle instead of the beginning. Resilience, as it is currently defined in social contexts, is essentially a concept for understanding decision-making under uncertainty. Where current conceptualisations have jumped into the middle is that the onus has been put on complexity, thereby making the need to account for complexity the central element of resilience. In terms of decision-making and choosing policies however, the fact that a system is complex is secondary to the fact that complexity causes *uncertainty* in our decisions, and we want to reduce these uncertainties. Having to deal with uncertainty is nothing new, since most planning decisions are "conducted in a state of relative ignorance of the full behaviour of the system being designed" (Petroski, 1994). What is important is that decision-makers fully understand what is to be achieved, and what is to be avoided during the formulation of the problem. If resilience is to be a concept that is useful for dealing with uncertainties, then rather than adopting a general, holistic approach, it probably would be more useful if policies were directed towards a specific goal. This most likely means that resilience would need to shift from being defined as a general system property, to one that refers to specific issues, such as for example flooding. By having a more specific definition of resilience, it is possible - through extensive statistical modelling - to sort through the *white noise* variables prevalent in the real world, and identify truly informative parameters that can change outcomes, such as preventing or reducing floods. Thus, rather than assuming that *anything* can happen, as is the case under a holistic approach to resilience, a targeted approach informed by statistical analysis would allow policy-makers to focus on the most relevant factors that can affect policy results, thereby reducing both the underlying uncertainties of their decisions, as well as improving the effectiveness of policies.

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Appendix A

People interviewed for case studies

People in national and strategic roles

- Lord Chris Smith - Environment Agency
- Colin Smith - Defra
- Nick Gupta - Environment Agency
- Paul Murby - Defra
- Duncan Huggett - Environment Agency
- Ruth Ashton-Ward - Defra

People directly involved in Holnicote project

- John Buttivant - Environment Agency
- Rachael Hill - Environment Agency
- Nick Lyness - Environment Agency
- Nigel Hester - National Trust

People directly involved in Pickering project

- Beckie Bennett - Ryedale District Council
- David Summers - Ryedale District Council
- Jon Bates - Environment Agency

- Jeremy Walker - NYMNPA/Environment Agency
- Mark Scott - Environment Agency
- Lucy Huckson - Environment Agency
- Mike Potter - Pickering Civic Society
- Phil Long - Ryedale District Council
- Tom Nisbet - Forest Research/Forestry Commission

Appendix B

Locations included in statistical models

Amesbury	Bingley	Blandford Forum	Boroughbridge
Bradford	Bradford on Avon	Bridgwater	Brightlingsea
Brighouse	Burnham on Crouch	Burnley	Carlisle
Carnforth	Castleford	Chertsey	Christchurch
Cookham	Datchet	Dewsbury	Dorchester
Edenbridge	Eton	Fordingbridge	Henley on Thames
Highbridge	Keighley	Kendal	Kessingland
Keynsham	Knottingley	Lancaster	Leeds
Leatherhead	Lowestoft	Maidenhead	Maidstone
Malton Norton	Marlow	Martlesham	Molesey
Newbury	Oxford	Paddock Wood	Padiham
Penrith	Purley on Thames	Reading	Salisbury
Selby	Shepperton	Shipley	Skipton
Staines upon Thames	St. Osyth	Sunbury on Thames	Tadcaster
Taunton	Tonbridge	Wallingford	Wareham
Wetherby	Wimborne Minster	Windsor	Wivenhoe
Wooburn - Bourne End	Woodbridge	York	

Appendix C

List of Abbreviations

- SES - Socio-ecological System
- CAS - Complex Adaptive System
- FRM - Flood Risk Management
- DRR - Disaster Risk Reduction
- UNISDR - United Nations International Strategy for Disaster Reduction
- FEMA - Federal Emergency Management Agency
- Defra - Department for Environment, Food & Rural Affairs
- NFM - Natural Flood Management
- PFDG - Pickering Flood Defence Group
- P&DCS - Pickering and District Civic Society
- LWD - Large Woody Debris Dam
- EA - Environment Agency
- PES - Payment for Ecosystem Services
- NT - National Trust
- NYMNPA - North York Moors National Park Authority
- FC - Forestry Commission

- RFCC - Yorkshire Regional Flood and Coastal Committee
- LLFA - Lead Local Flood Authority
- SFA - Settlement Funding Assessment
- LSSG - Local Service Support Grant
- NYCC - North Yorkshire County Council
- CAP - Common Agricultural Payments
- IAPP - International Association for Public Participation
- FOI - Freedom of Information request
- LDLG - Ryedale District Land Drainage Liaison Group
- IDB - Internal Drainage Board
- YDPB - Yorkshire Derwent Partnership Board
- TEEC - Transport, Economy and Environment Overview and Scrutiny Committee
- RDC - Ryedale District Council
- NFU - National Farmers' Union
- SDC - Scarborough District Council
- OLS - Ordinary Least Squares
- ABI - Association of British Insurers
- RRC - River Restoration Centre
- SWMP - Surface Water Management Plan
- SuDs - Sustainable Urban Drainage System
- LRF - Local Resilience Forum
- MAFP - Multi-agency Flood Response Plan
- LFRM - Local Flood Risk Management Plan
- ONS - Office for National Statistics

- ASHE - Annual Survey of Hours and Earnings
- DCMS - Department for Culture, Media & Sports
- IDBR - Inter Departmental Business Register
- NCVO - National Council for Voluntary Organisations
- OECD - Organisation for Economic Co-operation and Development
- IMD - English Index of Multiple Deprivations
- BRE - Building Research Establishment Group