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What is Uncertainty and Why Does it Matter?

Ian Scoones

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About PASTRES

PASTRES (Pastoralism, Uncertainty and Resilience: Global Lessons from the Margins) is a research project that aims to learn from the ways that pastoralists respond to uncertainty.

PASTRES seeks to apply such 'lessons from the margins' to global challenges in other domains, including financial systems, infrastructure management, disease outbreaks, climate change, mobility and migration, and conflict and security.

The project's case studies are in pastoral areas of China (Qinghai), Italy (Sardinia) and Kenya (Isiolo). PASTRES is supported by an Advanced Grant from the European Research Council (ERC).

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Contents

Abstract

Uncertainty defines our times. Whether it is in relation to climate change, disease outbreaks, financial volatility, natural disasters or political settlements, every media headline seems to assert that things are uncertain, and increasingly so. Uncertainty, where we do not know the probabilities of either likelihoods or outcomes, is different to risk, the implications of which are explored in this paper through five different ways of thinking about uncertainty, derived from highly diverse literatures encompassing societal, political, cultural, practice and individual perspectives.

The paper continues by examining how these perspectives relate to four domains: finance and banking; critical infrastructures; disease outbreaks and climate change; natural hazards and disasters. Reflecting on these experiences, the paper argues that embracing uncertainty raises some fundamental challenges. It means questioning simple, linear perspectives on modernity and progress. It means rethinking expertise and including diverse knowledges in deliberations about the future. It means understanding how uncertainties emerge in social, political and economic contexts, and how uncertainties affect different people, depending on class, gender, race, age and other dimensions of social difference. And, if uncertainty is not reducible to probabilistic risk, it means a radically different approach to governance; one that rejects control-oriented, technocratic approaches in favour of more tentative, adaptive, hopeful and caring responses.

The paper concludes by asking whether we can learn from those who live with and from uncertainty – including pastoralists in marginal settings – as part of a wider conversation about embracing uncertainties to meet the challenges of our turbulent world.

1. Introduction

Uncertainty defines our times. Every media headline seems to assert that things are uncertain, and increasingly so – be it climate change, disease outbreaks, economic conditions or political settlements. Helga Nowotny, in her book, *The Cunning of Uncertainty*, argues that uncertainty is 'written into the script of life' (2015: 1). Many years before, Mary Douglas (1986a: 172) argued that '…unwrapping the gifts we receive from randomness, thriving on the cusp of uncertainty and knowing when is the right moment to act, delay or forgo action are different ways of embracing uncertainty'. But how should we understand 'uncertainty', and why does it matter? Are our societies equipped for responding to seemingly accelerating uncertainties across domains?

The conventional, managerial and technocratic approach is to construct challenges as risks – where the probabilities of future outcomes are known, or at least can be estimated. The paraphernalia of risk assessment and management are familiar, derived from engineering approaches. These are good for some challenges – such as the designing of a bridge or road – but not for others. A risk-focused approach implies the future is controllable and that a modernist vision of progress is achievable, if only effective science and technocratic-institutional control are applied.

But when future outcomes are not known, when there are disputes about what outcomes are desired and when indeterminacy prevails in complex, interconnected systems, then such approaches fail. To assume that they will work is potentially dangerous. In this wider, and much more common condition of uncertainty – or more broadly 'incertitude' – greater humility and vigilance are required. Knowledge about uncertainty is co-constituted with social, institutional and political orders, so it really matters how we understand and respond to the multiple conditions of uncertainty. This has huge implications for the practices of science, management and policy, with consequences for how institutions and governance arrangements function. A linear, hierarchical, modernist vision of progress is thus challenged, opening up questions about how we navigate the world in new ways in the context of uncertainty.

This paper offers a necessarily highly selective review of different ways of thinking about uncertainty, drawing on a range of disciplinary perspectives and explorations in different fields.[1] It argues for a tighter analytical differentiation of 'uncertainty' and a dissection of its multiple dimensions, and suggests that new thinking and practice is required for living with and from uncertainty (Scoones 1994; Krätli Schareika 2010). Unlike what has happened too often in responses to challenges of resilience and sustainability, this means going beyond a technocratic managerialism to a more fundamental recasting of practices, institutions and policies that fundamentally challenge simplistic visions of modernising progress.

In order to achieve such a reframing, the paper argues that looking across fields is both illuminating and instructive. Here I reflect on lessons from responding to volatility in banking and finance networks; managing reliability in critical infrastructures; thinking about early warning and preparedness around infectious disease outbreaks and reflecting on the representation of vulnerability in climate and disaster

[1] This paper has been written as a background review for the European Research Council-funded PASTRES project (Pastoralism, Uncertainty, Resilience: Global Lessons from the Margins, www.pastres.org), and particularly as part of the training programme for the six PhD students who have joined the project. The project is exploring how pastoralists live with and from uncertainty in Qinghai in China, Sardinia in Italy and Isiolo in Kenya, as well as western India, southern Ethiopia and southern Tunisia. Lessons from pastoralists, we argue, may help others working in other domains to develop more effective responses to uncertain contexts. This paper is a first part of trying to develop a conversation across domains, and is an input into the ESRC STEPS Centre's symposium on 'The Politics of Uncertainty' in July 2019.

responses. Such diverse fields offer important convergent insights that, together, push us towards a fundamental rethinking of conventional responses to uncertainty.

Further, the paper argues that it is also crucial to gain insights from those who have long confronted environmental, market and governance uncertainties – such as pastoralists living in marginal areas. If modernist practices and institutions forged with an expectation of certainty – or at least risk management – have failed, then how can alternative, culturally embedded forms help us to rethink?

In the next section, the paper asks 'what is uncertainty?' and offers a set of reflections on definitions, before posing some guiding questions. The following sections introduce five ways of thinking about uncertainty, derived from a review of the voluminous literature on the theme. Sources come from across different disciplinary traditions that are frequently not brought into conversation with each other. Next, the paper turns to examining responses to uncertainty in different domains – as mentioned, in finance and banking; critical infrastructures; disease outbreaks; and climate and disaster risk reduction. A set of emerging overarching themes are then highlighted, before the paper concludes with a brief reflection on some core characteristics of what embracing uncertainty might mean in practice.

2. What is Uncertainty?

There are long traditions of reflecting on uncertainty. These include philosophical traditions of scepticism and creativity, ranging from Socrates to Erasmus to de Montaigne (Ravetz 2008); the quantum view of physics, from Heisenberg to Schrodinger (Buckman 2008); and perspectives in economics, from Keynes to von Hayek to Marx (Diamond and Rothschild 2014). In different ways, all point to the challenges of human control and technocratic management, and so confront a Cartesian and modernist rationalism. Nobel prize-winning physicist Richard Feynman neatly captured the ambitions of science to embrace uncertainty:

> It is imperative in science to doubt; it is absolutely necessary, for progress in science, to have uncertainty as a fundamental part of your inner nature. To make progress in understanding, we must remain modest and allow that we do not know. Nothing is certain or proved beyond all doubt. You investigate for curiosity, because it is *unknown*, not because you know the answer. (Feynman 1956/2001: 247–8)

This sentiment is echoed in biologist Stuart Firestein's book, *Ignorance: How It Drives Science*. 'Real science', he says 'is a revision in progress, always. It proceeds in fits and starts of ignorance. Being a scientist requires having faith in uncertainty, finding pleasure in mystery, and learning to cultivate doubt.' (2012:9)

2.1. Statistics, Economics and Management: From Risk to Uncertainty?

Despite the frequent hailing of doubt and uncertainty as central to scientific creativity, the practice and application of science and technocracy can be quite different. As Ian Hacking (1990) argues in *The Taming of Chance*, statistics emerged as a mechanism of control through surveys, censuses and regulatory disciplining. The origins of states, as the term implies, is rooted in statistics, and therefore in counting, predicting and controlling (Porter 1986). In '*Seeing like a State*', James Scott (1998) argues that the state requires metrics, planning and control systems. Settled city states in these ways organise to fend off the violence and volatility of the outsider 'barbarians' (Scott 2017). State-craft is bound up in creating certainties where often there were none.

In economics, Frank Knight (1921/2000: 311) long ago pointed to the difference between uncertainty and risk, in relation to the ability to assign probabilities to outcomes. He argued:

> …profit arises out of the inherent absolute unpredictability of things, out of the sheer, brute fact that the results of human activity cannot be anticipated, and then only in so far as even a probability calculation in regard to them is impossible and meaningless.

In his landmark *General Theory*, John Maynard Keynes (1936) argued that economic models are inadequate, so we must rely on the 'animal spirits' of intuition and judgement for decision-making:

> Even apart from the instability due to speculation, there is the instability due to the characteristic of human nature that a large proportion of our positive activities depend on spontaneous optimism rather than mathematical expectations, whether moral or hedonistic or economic. Most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as the result of animal spirits—a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities. (1936: 161–2)

Friedrich von Hayek also accepted the fundamentals of uncertainty, but argued that market relations were the best route to resolution. Kenneth Arrow equally argued for the centrality of uncertainty considerations in economic decisions (Arrow 1963; Arrow and Lind 1970; Machina 1987), reflecting later: 'Vast ills have followed a belief in certainty… When developing policy… caution is needed because we cannot predict the consequences' (Arrow 1992: 46). Marxist economic theory of course accepted irreducible uncertainty as central to dynamic, dialectic change, the result of an ever-lasting process of agitation derived from competition among different classes and capital (Dunn and West 2013).

In other words, before the rise of a narrowly defined mathematical economics, premised on equilibrium thinking, uncertainty as a concept – even if deployed in different ways – was central to economic theory, and to wider, applied policy thinking (Akerlof 1970). Yet, standard economics textbooks rarely mention uncertainty and, if they do, they conflate risk with uncertainty.

However, changes may be afoot. Popular interventions in recent years have started to argue for the distinguishing of signal and noise (Silver 2012), the importance of 'fat-tailed' distributions (Taleb 2012), black swan events (Taleb 2007), and, for some, even the rejection of probabilistic thinking altogether (Ayache 2010). This has, in turn, been combined with a greater appreciation of the problems of poor applications of conventional statistics and inappropriate risk calculations (Freeman and Spiegelhalter 2018). More broadly, such themes as the 'architecture of error' (Hughes 2014), 'being wrong' (Schultz 2011) and the 'adventures of serendipity' (Merton and Barbar 2011) have been highlighted.

The ongoing debates between objective and subjective approaches to statistical analysis highlight the importance of understanding uncertainty. In the frequentist approaches of traditional 'normal' statistics, the assumption is that likelihoods can be assigned, as in the random numbers generated by the rolling of a dice. This 'aleatory' approach to uncertainty is contrasted with an 'epistemic' approach, where probabilities express a 'degree of belief' in an event, which may change as learning takes place, and new information is accumulated. This Bayesian approach, where beliefs, subjective perceptions and learning are important, provides a major challenge to frequentist assumptions in statistics. In Bayesian approaches, alternative models, and so understandings of uncertainty, emerge through incremental, sequential learning processes. Most systems do not replicate dice-throwing or simple gambling games and there are always unknown parameters to learn about, with prior distributions influencing future outcomes (O'Hagan 2004). This matters because models that take different approaches may result in very different recommendations about engineering safety, for example (Der Kiureghian and Ditleven 2009). Sequential statistical analysis therefore allows new experiments or models to be designed based on previous experiences, as beliefs are updated. Building on such insights, fuzzy logic approaches, agent-based modelling and dynamic, non-equilibrium analysis are increasingly used (Lunn *et al*. 2012).

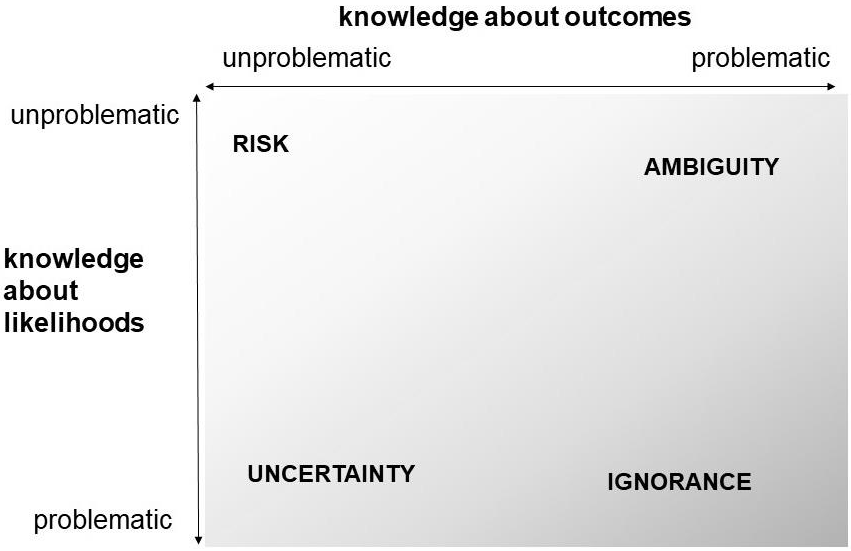
Of course, practical appreciations of the implications of uncertainty, complexity and the importance of learning have long been evident. Albert Hirschman (1971), for example, in his explorations of the administration and management of development in Latin America was perhaps the most articulate exponent. He argued against narrow, disciplinary approaches and for greater latitude, with a 'bias for hope' and a 'passion for the possible', based on diverse experimentation, learning from history and sequential decision-making. Such perspectives have become popular more recently in arguments for 'adaptive management' of 'complex socio-ecological systems' (Walters 1986; Ludwig *et al*. 1993; Gunderson 1999; Folke *et al*. 2005), as well as 'experimental governance' (Sabel and Zeitlin 2010; Evans 2011; Hilden *et al.* 2017; see below), and a wider advocacy of 'complexity-aware development' (Ramalingam *et al*. 2014).

2.2. Constructing Uncertainty: A Politics of Knowledge

Constructivist perspectives on science and policy have long argued for the necessity of embracing indeterminate contexts, and moving beyond simple risk framings towards subjective perspectives on uncertainty (Wynne 1992a; Stirling 1999). This has important consequences for expertise, law and regulation (Jasanoff 1987). A 'post-normal' science, Silvio Funtowicz and Jerome Ravetz (1990) argue, is required when conditions are uncertain, values are in dispute, the stakes are high and decisions are urgent. This entails engaging an 'extended peer community' to be involved in scientific disputes and policymaking (Ravetz 1999).

Andy Stirling (1999) contrasts risk, where the probabilities of both outcomes and their likelihoods are known (or are deemed unproblematic), with uncertainty, where likelihoods are unknown, as well as ambiguity, where outcomes are contested, and ignorance, where, in the words of former US Defense Secretary Donald Rumsfeld, 'There are unknown unknowns, the ones we don't know we don't know'.[2] The simple heuristic presented in Figure 2.1 provides a useful unpacking of what Stirling identifies as four dimensions of 'incertitude'. These dimensions are states of knowledge, not states of nature. They are views about the world, from particular perspectives, not statements about how the world is (Stirling 2019). This has profound implications for policy and practice, as will be explored below.

Figure 1: Four dimensions of incertitude



Source: Andy Stirling, reproduced from Leach *et al.* (2010: 53)

[2] Press conference, 2002: https://www.youtube.com/watch?v=GiPe1OiKQuk

Too often, as Stirling (2003; 2008a; 2010; 2019) argues, power and politics close down towards a risk framing. As we navigate our way to choices and decisions, institutionally embedded procedures, protocols, methods and techniques influence practices and what is considered taken-for-granted knowledge. Social and political orders, alongside socio-technical imaginaries of the future, are co-constructed with diverse knowledges about the world (Jasanoff 2004; Jasanoff and Kim 2015). Disciplinary biases in favour of, say, risk assessment and management and modelling techniques, constructing an engineering view of the world, end up pushing and pulling their users towards probabilistic solutions: towards a risk framing and away from an embracing of uncertainty. Frequently, planning regimes and goal-oriented management systems deny multiple possible outcomes. Ambiguities often emerge where there are disputes between different people about possibilities under conditions when likelihoods of each can be estimated. A more challenging, and perhaps more common, situation is when knowledge about both possible outcomes and their likelihoods is problematic. Under such conditions of ignorance, navigating future pathways of change requires a very different approach to standard risk management. In other words, power and politics are central to the construction of uncertainty as a state of knowledge.

This simple heuristic suggests that there are multiple dimensions of incertitude and that closing down to risk is highly problematic, and potentially dangerous. As Stirling (2019) states:

> Across technology, health, environment and national and global economies, loud voices on all sides vie to express messily unknown subjective uncertainties as if these were neatly quantified objective risks. However they are seen, the stakes are very high. Huge forces are pressuring for a state of *uncertainty-denial*. What all this means, is that the drive for ostensibly objective probabilities is not innocent. Even if inadvertently, it helps shape reassuring policy storylines. And, to those interested in '*business as usual*', the apparent authority and clarity of simple numbers can offer a precious sense of stability.

Many approaches that dominate policy discussions make the same errors. For example, the financialisation of risk through techniques of insurance has this effect, as do many 'disaster risk and reduction' frameworks, as discussed further below. The result is a failure to acknowledge all dimensions of incertitude, where a greater appreciation of uncertainty, ambiguity or ignorance is required. This may result in constructing a sense of security in what Michael Power (2004; 2007) identifies as a contemporary tendency towards 'the risk management of everything', when in fact attention to unknowns is imperative. The consequences can be devastating when events unfold that individuals and institutions are not prepared for – whether a financial or banking crisis or a global disease outbreak, as discussed further below.

To counter a closing down to risk, diverse sources of knowledge are therefore essential for addressing all dimensions of incertitude. A technical, modernist perspective, typified by the dominant risk framing, relies predominantly (at least in theory) on what Greek thinkers such as Aristotle defined as '*techne*', a formal technical knowledge. Such knowledge in turn may be rooted in systematised theoretical understandings, often derived from accredited expert sources, 'episteme'. This contrasts with '*phronesis*', seen as 'practical wisdom', rooted in context-dependent, experiential knowledge, linked to values and practices, and '*metis*', a more craft-based practical common sense (Scott 1998).

Combining approaches, escaping the straitjacket of modernist expertise, is seen to generate a necessary, more 'subtle intelligence' for addressing uncertainty (Nowotny 2015: 137). This in turn requires a radical reappraisal of method in the social sciences if the consequences of 'mess', and 'vague, diffuse or unspecific, slippery, emotional, ephemeral, elusive or indistinct' worlds are to be understood (Law 2004: 2), requiring triangulation and deliberation among contrasting viewpoints.

Many philosophical traditions of knowledge-making exist, even within Western cultures. For example, reflective, pragmatist perspectives – from John Dewey (1910) and others – or those who emphasise

engaged 'communicative rationality', such as Jürgen Habermas (1984), or world-making (Goodman 1978). Each argues for a different stance. Alternative, cultural-religious belief systems from other parts of the world provide an even greater richness and plurality of perspectives on uncertainty, whether from different strands of Christianity, Buddhism, Hinduism or Islam (Taylor 2007; Batchelor 2015). Wider concerns with emotion, affective practices and spiritual belief, in turn, offer insights on the debate about uncertainty, and the importance of doubt, impermanence and belief.

Drawing on different styles of knowledge construction also allows new perspectives to arise, whereby uncertainty can be recast as a resource for the future, and a locus for action and possibility. For example, in *The Human Condition,* Hannah Arendt (1958) argues for bringing the future into the present, with islands of uncertainty creating the possibilities for action. This is a theme echoed by the contemporary writings of Rebecca Solnit (2016; 2017), who envisages creating 'hope in the dark', often through the process of 'getting lost'. In a similar vein, by grappling with the future 'as cultural fact', Arjun Appadurai (2013: 3) argues that building a picture of the historical present 'can help us find the right balance between utopia and despair'. A hopeful, creative and positive construction of uncertainty – as opportunity and a resource for action – is suggested, countering the negative connotations of risk and uncertainty as challenge or danger.

2.3. Emerging Questions

Some important questions therefore arise around how we understand and frame uncertainties and how these are presented in the world (Zaloom 2004). These highlight, most fundamentally, the contrast between epistemological and ontological uncertainty and between subjective and objective understandings (Walker *et al.* 2003; Stirling 2019). These debates raise questions around how we deal with ignorance (Smithson 1989; Gross 2007, 2010; Rayner 2012), non-knowledge or negative knowledge (Knorr-Cetina 1999) in challenging policy settings.

Such reflections raise issues around the politics and governance of uncertainty, and pose questions about how we define modernity and progress. In particular, we must ask: is the linear vision of progress, linked to a dominant, technocratic, controlling order, challenged by a deeper recognition of uncertainty? And, in turn, what frames become appropriate in seeking alternatives? What alternative cultures, practices, institutions and politics are suggested, embedded in different (including non-Western) histories and traditions? What more can we learn from alternative cultures of uncertainty that construct the world in different ways, through different histories, social imaginaries, traditions of thinking and everyday practices? How does uncertainty play out through the repertoires of individuals, institutions and wider networks, and what tensions and dissonances arise across different spaces of incertitude?

These are of course huge questions, and one short review essay cannot broach them in their entirety. The aim here is more to suggest an approach for further enquiry, bringing together diverse perspectives and to encourage an onward conversation, rather than offer anything resembling a synthesis. What I hope comes over, however, is a sense that asking 'what is uncertainty?' is as useful as it is urgent. The turbulent times we live in clearly require new thinking on practice, policy and governance.

3. Five Ways of Thinking about Uncertainty

The literature on risk and uncertainty is massive, and there is no attempt to be comprehensive in what follows. Here I use the term 'uncertainty' to illustrate a range of conditions, including ignorance and ambiguity that are distinct from 'risk'. However, it is the literature on 'risk', broadly understood, from which much of this discussion emerges.

Rising anxiety among particularly Western publics and policymakers about the threats from environmental pollution or the consequences of new technologies (such as nuclear power) has been matched by growing interest in 'risk analysis', particularly from the 1970s (Burgess 2016). This has accelerated in recent times, as pressing concerns have all been framed by considerations of risk and uncertainty (Ansell *et al.* 2016) – such as climate change and natural disasters (Alfieri *et al*. 2015; Aven and Renn 2015); crime, conflict and terrorism (Anderson 2006; Aradau and Munster 2007; Amoore and De Goede 2008); and volatility in financial markets (Battiston *et al*. 2012; Acemoglu *et al*. 2015).

In 1969, Chauncey Starr was among the first to advocate for a technical risk analysis approach (Starr 1969). This evolved into a number of traditions, associated with different regulatory systems, notably the emergence of risk assessment, management and communication in the USA (Millstone 2007). These drew on actuarial approaches linking to individualised harm from specific hazards to more systemic, collective impacts of interconnected, global risks (Royal Society 1992). A variety of 'risk governance' approaches also emerged (Krimsky and Golding 1992; National Research Council 1996; Renn *et al*. 2011; Renn 2017). Yet, as Knight (1921) established nearly a century ago, risk is not the same as uncertainty. Indeed, more than 30 years ago, Mary Douglas observed, 'Every choice we make is beset by uncertainty. That is the condition of human knowledge. A great deal of risk analysis is concerned with trying to turn uncertainties into probabilities' (1986a: 42).

In the following sub-sections, I outline five overlapping ways in which this debate in science and policy has been interpreted and challenged. These are societal, political, cultural, practice-based and individualist perspectives on risk and uncertainty. Each has a huge literature associated with them, and, despite the long reference list, I am only highly selective in what follows. Each area of literature, I argue, offers some important insights that can be drawn upon in illustrating, 'what is uncertainty, and why does it matter?'

3.1. Societal Perspectives

With the publication in Germany of *The Risk Society* in 1986, Ulrich Beck (1992) provoked a major debate on the implications of uncertainty on society and politics. In the aftermath of the Chernobyl nuclear disaster, he argued that pervasive risks, emerging as a consequence of modernity, were restructuring how politics were being conducted. Risk as a resource was becoming vital for capitalist expansion, he argued. A 'risk society' challenged conventional notions of expertise, and so required a rethinking of institutions, as well as policies towards precaution and sustainability (Beck 1992; Lash *et al*. 1996; Lash 2000; Bulkeley 2001; Mythen 2018). In the risk society, risks emerge as the unintended consequences of modernity, which conventional institutions of industrial society cannot address. A political focus on the distribution of risks (as 'bads') means that class becomes a less salient analytical category. Instead, through a process of public reflection, a new 'sub-politics' emerges as part of what Beck terms 'reflexive modernisation'.

The Risk Society, and the multiple sequels, including arguments for a 'world risk society' (Beck 2009), 'reflexive modernisation' (Beck *et al*. 1994) and a 'cosmopolitan society' (Beck 1996; 2002; Beck *et al*. 2013; Beck and Levy 2013; Levy, 2018), continue to provoke much discussion in academic and policy circles, especially in Europe (Mythen 2004, 2005; Mythen *et al*. 2018). Many questions have been raised. Was this a narrow interpretation based on a northern European experience? What about other cultural, historical and socioeconomic contexts (Adam *et al.* 2000; Caplan 2000; Leach *et al*. 2002)? Was the emergence of a 'risk society' the consequence of a particular set of events, cultures and institutional experiences, or could this moment be more generalised as a distinct period of world history?

It may be that our current, turbulent times require such a fundamental rethinking of society. As Bauman (2013) argues, we exist in 'liquid times', where the certainties of previous frameworks no longer apply. 'Nomadism', he claims, is a trait of 'liquid modern humans', and is characterised by flows between occupations, identities and networks. Life is shifting, mobile, provisional and improvised, rather than

structured, sedentary, fixed and static. The birth of a 'network society' (Castells 1996) is accelerated by globalised economies, migration and technological connectivity (Wajcman and Dodd 2016), with diverse relationships connected 'rhizomatically' (Deleuze and Guattari 1980).

However, just as with debates about 'risk society', such reflections on 'modern' (read 'Western') society have important precedents elsewhere. The features of Bauman's 'liquid modernity' replicate many characteristics of pastoral societies, which have, by necessity, always lived with and from uncertainty (Scoones 1994; Krätli and Schareika 2010). Variability is a resource on which pastoralism must thrive, and confronting uncertainty is therefore a way of life, not a problem to be overcome (Krätli *et al*. 2015).

In terms of wider social science debates on risk and uncertainty, competing conceptual framings have been discussed. By way of example, in explaining the rise of debates about risk, is a 'risk society' or a 'governmentality' framing more appropriate (Mythen and Waklate 2005)? Is there really such a rupture from classic class dynamics and the functioning of capitalism as suggested by *The Risk Society*'s sweeping generalisations (Stanley 2013; Curran 2013, 2106, 2018)? Even if 'manufactured' risks are important (Michaels 2006), surely the natural world remains important? Risk (and uncertainty) may be important in restructuring society, but perhaps in a less universalising manner than is sometimes argued (Lupton 1997; Tulloch and Lupton 2003; Taylor-Gooby and Zinn 2006a).

A constructivist perspective on risk, central to a long tradition in science and technology studies, offers a more nuanced perspective, but also with significant societal implications. As Sheila Jasanoff argues (1993; 1999), a point echoed by Brian Wynne (1992a), risks are 'constructed' and are 'manufactured' through particular styles of politics and via institutional interventions. This is not to say that hazards are not real, but understandings and responses are inevitably and variably mediated. This is a theme emphasised by Niklas Luhmann (1993, 1997), another influential German sociologist, who argues that the notion of risk emerges in modernity to replace 'danger' and predetermined future outcomes.

Science and technology studies critiques emphasise in turn that a technocratic reading of risk, as one that involves a gap of understanding between science and publics, is problematic (Wynne 1992b; Rayner 2012). Social and cultural reflections emphasise the need to move beyond individual choice perspectives, often central to reflexive modernisation, to thinking about how collective, cultural and institutional dimensions affect how societies respond to risk and uncertainty (Caplan 2000; Nugent 2000).

What is undisputed is a recognition of the wider penetration and assimilation of risk thinking and practice in society. The rise of an 'audit culture', and a plethora of forms of accounting and assessment, act to obscure complexity and hide deeper uncertainties, for example (Power 2007). As Louise Amoore argues, an entire range of commercial operations – from risk management consultancies to data analysis firms to logistics companies – has become involved in the functioning of state security, deriving from a political focus on the possibilities of low likelihood, high consequence events, spanning terrorism to financial collapse and other human-induced disasters. A technocratic, control-oriented style of governance is reinforced by the role of specialisms in expertise that defines the future. Technical-managerial responses, such as insurance and liability law, are favoured over more deliberative governance approaches and inclusive governance principles such as precaution (Voss *et al.* 2006; Stirling 2008b; Renn *et al.* 2011; Renn 2017).

Debates about society in the Anthropocene, with human–nature relations recognised as inextricably entwined, reflect these tensions. Some argue that the Anthropocene excuses a style of 'cockpit', control-oriented, global governance in the name of protecting the environment from human depredations (Biermann 2014; Hajer *et al.* 2015); while for others an acceptance of the influence of uncertain, uncontrollable nature offers opportunities for a greater humility and enhanced human–society relations (Palsson *et al*. 2013; Lövbrand *et al.* 2015; Swyngedouw 2015). What is for sure is that rapidly changing environmental and economic conditions mean that debates about responsibility and

accountability are brought into sharp relief (Giddens 1999). Such discussions in turn suggest new forms of citizen-state-society relations, requiring new styles of governance in the face of uncertain futures.

3.2. Political Perspectives

Just as debates around risk and uncertainty are seen to construct society, they also generate styles of politics. In his polemic on the value of market liberalism, Bernstein (1998) famously argued in *Against the Gods* that uncertainty 'makes us free', liberating entrepreneurs from the shackles of state control. Others frame the political challenge around 'calculated futures', where the technocracy offers planned guidance and response in the face of uncertainty, creating an array of political technologies and forms of governmentality, where governmentality is understood as the 'conduct of conduct' – the way that techniques of government are deployed to produce governable subjects (Burchell *et al*. 1991; Dean 2010). Framing risk thus means framing politics, and what emerges are different forms of biopolitics, understood – following Michel Foucault (2007; 2008) – as the interaction of sovereignty, discipline and governmental management, which together have 'population as its main target and apparatuses of security as its essential mechanism' (quoted in Amoore 2013: 65).

Discussing the history of insurance, François Ewald (1991) showed long ago how risk is co-constructed with politics, from collaborative mutual societies to individualised actuarial logics, through the governmental techniques of indemnities, indices and liabilities. Such political technologies create subjects (the insured population) and objects (the hazards) and discipline responses to risk in particular ways, generating moral orders, obligations and responsibilities (cf. O'Malley 1996, 2003). These responses are, however, not set or given, but are negotiated in different political systems. Governing emerges through such forms of biopolitical disciplining, as well as through the exercise of sovereignty, via the legal system and the state, and through market regulation (Dillon 2007; Samimian-Darash and Rabinow 2015).

In relation to contemporary environmental questions, processes of marketisation (Çalışkan and Callon 2010) – involving governing at a distance via market mechanisms – create new political relationships around the risks and uncertainties of, say, climate change, air pollution or environmental degradation. In this context, 'contingency' becomes an important discourse (Dillon 2007; Oels 2013), making the ungovernable governable (Ziederman 2012; Ziederman *et al*. 2015).

When conditions are uncertain, approaches to 'governance' – how power, authority and influence are deployed to affect public policies and decisions – must also change. For many this requires far more caution and much more rethinking when it comes to relying on linear, technocratic approaches, embedded in political-bureaucratic systems. Flexible, adaptive governance has been proposed, resulting in a large literature, for example, on experimental approaches (e.g. Greenberg *et al*. 2003; Sabel and Zeitlin 2010; Overdevest *et al*. 2010; De Búrca *et al.* 2014; Overdevest and Zeitlin 2014; Laakso *et al.* 2017; Kronsell and Mukhtar-Landgren 2018; Voss and Simons 2018; Rangoni 2019).

How risks and uncertainties, and their material effects, are experienced are fundamentally affected by who people are, and how justice and freedom are understood (Douglas 1986a). While Beck argued that class, and so wealth and asset ownership, should no longer be the focus for political economy, but instead 'risk positions' in relation to emerging modern risks, many have argued that such a perspective is unjustified (Zinn 2009; Curran 2013, 2018; O'Malley 2016). Indeed, class – and gender, age, race, education – become vital lenses through which to understand perceptions of and responses to risk and uncertainty (Braun 2003; Braun and McCarthy 2005; Gertel and Hexel 2018).

It has long been recognised that vulnerability must be understood not just in terms of hazard, but also the underlying social dynamics, asking who is vulnerable to what, and how are responses circumscribed by social-economic position and historical political economy (Blaikie *et al*. 2004; Adger 2006; Watts 2015). In the same way and discussed further below, risk and uncertainty must be explored in relation

to a wider political economy and ecology analysis, where social difference and the intersections with power and forms of governmentality are central to any analysis.

3.3. Cultural Perspectives

Of course, cultural perspectives on risk and uncertainty are deeply entwined with the sociological and political perspectives discussed above. Social anthropologists, nevertheless, have pushed our understandings in ways that encompass a wider range of non-Western societies, arguing for ideas of multiple modernities, forged in very different settings. That cultures are not the same, and are always changing, is stating the obvious; but how do cultural norms, practices and expressions shape the way that uncertainties are embraced?

In *Risk and Culture*, Mary Douglas and Aaron Wildavsky (1983) argue that a liberal, 'sectarian' worldview in Western nations emerged during the 1970s to highlight consumer and environmental risks. In 'cultural theory' and the discussions that have emerged (cf. Thompson *et al*. 1990; Douglas 1999), different archetypes are identified and demonstrated across a grid-group schema – individualist, fatalist, hierarchist and egalitarian – each said to define a culturally embedded form of behaviour in relation to risk.

Many have argued that simple grid-group categories fail to recognise the textured, context-specific nature of 'culture', as located in everyday practices (Tulloch and Lupton 2003). Drawing on the work of Pierre Bourdieu, the notion of 'habitus' is used to explain engrained predispositions towards styles of risk-taking (Hanappi 2011). Practical experiences based on long-held understandings of environments demonstrate how local – often tacit and experiential – knowledges are crucial for responding to uncertainties, as in Brian Wynne's classic discussion of how Cumbrian sheep farmers in the UK reacted to the radioactive fallout from Chernobyl (Wynne 1992b; 1996). He argues:

> Much of [the] conflict between expert and lay epistemologies centred on the clash between the taken for granted scientific culture of prediction and control, and the farmers' culture in which lack of control was taken for granted… The farmers assumed predictability to be intrinsically unreliable as an assumption and therefore valued adaptability and flexibility, as a key part of their cultural identity and practical knowledge.
> (1996: 67)

Understandings of and responses to uncertainty are thus inevitably wrapped up in people's intimate realities, historical memories, personal experiences and social identities.

Views of uncertain futures are also conditioned by wider belief systems (Da Col and Humphrey 2012; Da Col 2012). Religious and cultural notions of impermanence and transience, fate and destiny, divination and magic, all affect how risks and uncertainties are perceived and responded to. Astrologers, soothsayers, oracles, prophets, priests and their modern-day equivalents thus remain important purveyors and interpreters of arcane, specialist knowledge about the future (Geschiere 1997). Cultural understandings of pollution and purity can be linked to perceptions of danger as boundaries are transgressed (Douglas 1992, 1966), and can be culturally constructed as 'good' and 'bad' risks (Nugent 2000).

Rituals in this perspective can best be seen as part of performative storytelling of socially agreed narratives, central to collective ways of dealing with an uncertain world (Moore and Sanders 2003; Graeber 2012). David Graeber (2012), for example, reflects on Malagasy notions of destiny and notes the similarities with the cultural performance in finance markets. The occult, witchcraft and rumour are quintessentially modern, it is argued, not a reflection of backward fatalism, but a pragmatic, cultural response to uncertainty, shaped by media-scapes and global imaginaries (Comaroff and Comaroff 1993, 1999; Appadurai 1996). In increasingly anonymous urban contexts and with easier access to

communication, some contend that the possibilities of rumour and 'fake news' spreading are high, making accusations of witchcraft and the rise of the occult potentially more prevalent (Bonhomme 2012; Berthome *et al*. 2012).

Forms of sociality involving trusting relationships and of ongoing, repeated meetings and conversations – often linked to rumour and gossip – are seen as important in providing the generative conditions for responding to uncertainty (Newhouse 2017). Connected to a wider, social 'moral economy', the collective, networked response can be crucial. This may emerge from the mundane practices of interactions, be they in social gatherings, churches, drinking places or among extended families (Newhouse 2017). Complex forms of convivial sociality (like the earlier versions of 'sociability') construct the basis on which 'the economic', and wider responses to uncertain futures, are formed (cf. Gibson-Graham 2008; Bear *et al.* 2015). These forms of sociality, as a route to confronting uncertainty, starkly contrast with the individualised, marketised, technically governed contexts in other cultures, where a managerial risk culture dominates.

In what some regard as desperate situations plagued by uncertainties, others can see hope and more positive futures. Uncertainty thus creates space for action. Studies of African migrants' experiences link hope with uncertainty (Kleist and Thorsen 2016). The experience of continuous mobility, unclear rights and contested citizenship, sometimes in the aftermath of conflict and war, would, for many, be seen as a description of deep disenfranchisement. While anxieties and trauma arise from such uncertainties, there can also be positive hope – an escape, a liberation, a sense of freedom from danger or oppression. From such a standpoint, possibilities open up. The 'spectacular conjuring acts' of 'economies of appearances' are thus ways of making things happen, creating possibilities seemingly from nowhere (cf. Tsing 2000, 2011). Reflecting on African ethnographic cases, Elizabeth Cooper and David Pratten (2014: 1) see 'uncertainty as a structure of feeling – the lived experience of vulnerability, anxiety, hope and possibility, mediated through the material assemblages that underpin, saturate and sustain everyday life'.

Living for the moment, appropriating the future for the present, and making do in difficult circumstances are all ways of creating opportunities from uncertainty (Pedersen 2012). Different cultural constructions of time are also routes to address doubt and uncertainty, changing the relationship between now and the future, in ways that doubtlessly differ between places, genders and generations (Johnson-Hanks 2002; Guyer 2007; Nielsen 2014; Bear 2016). Cultural ideas of time affect how we view the future, and the ability to predict, anticipate and control outcomes. A radical departure from any Enlightenment view of time as linear, ordered and uni-dimensional means accepting collapsed, multi-layered time in conditions where change is accelerating. As Barbara Adam (1990, 1996) argues, this means seeing 'multiple processes simultaneously, embrac[ing] contradictions and paradoxes, the unknowable and unknown' (1996: 110). This requires engaging morally with the future: 'A simultaneous recognition of the intrinsic indeterminacy of the future, and our roles in shaping that future, impose on us all the duty to take responsibility for the future that we are creating' (Adam 1996: 100).

This in turn may open up hopeful opportunities for action. As Rebecca Solnit (2016: xii) so memorably argued in *Hope in the Dark*:

> Hope locates itself in the premises that we don't know what will happen and that in the spaciousness of uncertainty is room to act. When you recognize uncertainty, you recognize that you may be able to influence the outcomes – you alone or you in concert with a few dozen or several million others. Hope is an embrace of the unknown and knowable, an alternative to the certainty of both optimists and pessimists.

3.4. Practice Perspectives

Practices are central to the enactment of social, political and cultural responses to uncertainty (cf. Ortner 1984, 2005; Stengers 2005), seen often as part of a 'performance' (Butler 1997). The calculative practices of prediction and modelling, from this perspective, are central to the construction of many risk-oriented responses (cf. Knorr-Cetina and Preda 2006; Callon *et al*. 2007; MacKenzie *et al*. 2007; MacKenzie 2008, 2009; Callon, 2009). The risk heat maps, emergency preparedness plans and business contingency measures are all practices central to creating forms of 'biopolitical' governmentality associated with risk, threat and emergency (Collier *et al*. 2004; Lentzos and Rose 2009; Collier and Lakoff 2015). These contrast with alternative practices responding to uncertainty that create 'spaces of possibility'. In the context of urban development, such practices might include site visits, conversations among officials and affected people, and deliberation among diverse forms of expertise (Ziederman 2015).

The iterative, responsive, adaptive, practical modes of public administrators who must 'muddle through' (Lindblom 1959, 1966), or more actively improvise, invent and chart out possible options (Hirschman 1970, 1971), represent practices central to the everyday experience of 'street-level bureaucrats' (Lipsky 2010), among others navigating complexity and uncertainty each day. A contrast between root-style decision-making, which is rationalist and theoretical, with branch-style decision-making, which is strategic, pragmatic and incremental, thus emerges (Lindblom 1959, 1979) Rarely appreciated in the dominant frame of linear planning and top-down execution, such practices allow systems to change and development to happen, it is argued (Hirschman 1971). In times of crisis, but with no guarantees, things often 'don't fall apart' precisely because a range of unsung people hold things together (Grabel 2010, 2018).

In managing mess and generating reliability, and so avoiding potentially catastrophic accidents or systems failures, the practices of reliability professionals (Schulman *et al*. 2004; Roe and Schulman 2008; Roe 2013, 2016) and organisations (La Porte 1996) have been highlighted. Operating in the 'control rooms' of critical infrastructure facilities – energy supply companies, air traffic control towers and so on – 'reliability professionals' are vital.

Acting in a different way to the ground-level operators, field-based administrators and 'street-level' bureaucrats, they have important skills in 'recognizing system-wide patterns, formulating locally specific contingency scenarios and translating both patterns and scenarios in highly reliable services' (Roe 2016: 351). By operating across performance modes, they are able to manage (not attempt to clean up) policy messes and so assure reliability (Roe 2013, 2016; Roe and Schulman 2018). Again, such professionals are rarely acknowledged or appreciated. They do not have a formal job description, but their learned practices – working in loose networks with others – are essential to system operation, making sure key services are delivered, despite highly volatile, uncertain contexts. While the identification of reliability professionals has been most elaborated in the context of critical infrastructure operations, such practices – and the people and networks associated – are essential in any system where a reliable supply of outputs is required in complex, challenging, uncertain settings.

Whether these are pastoralists in African rangelands (Roe *et al*. 1998), farmers in West Africa (Richards 2018), humanitarian workers in conflict settings, healthcare workers (Khan *et al*. 2018), or those responding to disease outbreak emergencies in global health systems (Samimian-Darash *et al*. 2012; Lakoff 2017), similar principles apply. Thus, for example, farmers responding to the vagaries of the weather or the uncertainties created by external 'development projects' must generate improvised performances that help to respond to field conditions, as well as navigate a wider political economy (Flachs and Richards 2018). Managing mess (the complexity and uncertainty of the real world) requires the ability to track between wider context and micro-operation. Learning from cases, being alert to the unusual, networking with others and experimenting and innovating when a crisis is not in full swing, are all key features (Roe and Schulman 2008).

Organisational theorists have made similar points in relation to the use of tacit knowledge, craft practices, experimentation, mindfulness and shared sense-making as important in responding to complexity and uncertainty (March and Olsen 1975; Weick 1995; Weick and Sutcliffe 2011; Petterson and Schulman 2016). Ray Ison (2018) advocates a praxis perspective, where reflexive systemic sensibilities are central to addressing complexity and uncertainty in processes of transformation. All are, it is argued, essential features of successful organisations that must navigate the unknown.

A focus on practice directs attention to agency: how people choose to act in the world where knowledge and action are inseparable (Shove *et al.* 2012; Arora 2017; Arora and Glover 2017). Confronting uncertainties from 'nature' equally means going beyond a framing that sees external, biophysical hazards as independently generating risks and vulnerabilities. There are mutually co-constructed agencies at play. Nature and human action are intimately bound together, with human agents not simply working in isolation. Thus, interactions between human and non-human natures, bound up in extended actor networks, must necessarily become central to our understandings of how uncertainties are lived with (Law 1999; Latour 2005). In this view, multiple agencies and diverse practices link human–nature networks in ways that both generate and confront uncertainties as horizons of possibilities.

3.5. Individual Perspectives

Studies of risk have a long tradition of examining individualised risk perceptions – what some term the 'psychometric paradigm' (cf. Slovic *et al*. 1980; Fischoff *et al*. 1983; Slovic 1987). Tests aimed at eliciting individuals' perceptions are administered, and different categories of response – dread, safety first, blame – are surfaced or derived. Risk communication (Plough and Krimsky 1987), often based on the 'deficit model' (cf. Wynne 1992b), and discussions of the 'social amplification of risk' are frequently rooted in such individualist understandings (Kasperson and Kasperson 1996; Pidgeon *et al*. 2003). The individualist focus of much (Western) psychology is similarly reflected in such approaches (Ji *et al*. 2001; Loewenstein *et al*. 2001; Taylor-Gooby and Zinn 2006b; Penrod 2007), which unsurprisingly result in an emphasis on individualised risk responses through personal resilience, perseverance, tolerance, anticipation and so on (Bammer and Smithson 2008; Burgess 2018).

Recent developments in neurobiology and the understanding of brain function have similarly emphasised an individual, biological response to uncertainty. Studies have demonstrated neural representations of uncertainty (Hsu *et al*. 2005; Grinband *et al*. 2006), neurobiological responses to ambiguity (Bach *et al*. 2011; Bach and Dolan 2012), learning in the face of uncertainty (Knill and Pouget 2004; Hasson 2017), emotional responses to uncertainty (Tiedens *et al*. 2001) and anxiety about future risks and uncertainty (Grupe and Nitschke 2013).

Decision theorists again focus on individualised responses, very often based on gambling decisions (Heath and Tversky 1991; Fox and Tversky 1995) or game theory calculus (von Neuman and Morgenstein 1944). A focus on individual decisions evokes the importance of individualised mental heuristics in making choices (Tversky and Kahneman 1974; Kahneman and Tversky 1982). Such approaches, however, contrast with arguments for more intuitive responses to wider uncertainties, such as 'rules of thumb' (Heiner 1983), bounded rationality (Simon 1962, 1997), emotional responses (Tuckett 2011, 2018) and fictional expectation (Beckert 2013) – all linked to cultural influences on choice and perception (Otway and Thomas 1982). More complex, culturally embedded approaches to decision-making are revealed, rather than a straightforward contrast between risk-taking and risk-averse behaviours. Farmers, for instance, may follow a series of decisions in sequence (Ortiz 1967), initially opting for 'safety-first' solutions to secure basic food before taking more risks (Kunreuther and Wright 1974).

The focus on individual behaviour comes into tension with more social constructivist perspectives on behaviour. These argue that, while individual perspectives and actions are important, these need always to be seen as emerging from interactions with other people, institutions and wider society. Moral

attitudes to risk depend on socio-cultural experiences, which may differ quite radically within one community (Thompson 1984). Risk and values are inevitably co-constructed (Jasanoff 1999), making it crucial to reflect on how individual behaviour is conditioned by wider morality and values. Additionally, different people have contrasting mental agility, senses of preparedness and emotional resources to respond to uncertainties. Here a focus on the emotional and affective becomes important, embedded in wider social and cultural norms (Anderson 2006). These resources may be quite different across geographical location, class, gender, age and education, as people's abilities, experiences and capacities for living with uncertainties vary.

The sort of cultural metaphors, tropes and stories marshalled in thinking about uncertainty also differ across locations (Lackoff and Johnson 2008; Akerlof and Schiller 2010), and with significant effect. The use of metaphors, tropes and stories affect individuals' predispositions and ability to cope and respond. Similarly, narrative frames – storylines about the world – provide the basis for navigating uncertain change by individuals and groups; these may help to open up opportunities for positive change, or they may close down and shift towards despair and disaster (Beckert and Bronk 2018; Tuckett 2018).

Experiences matter. In the past, perspectives on living with, on or from uncertainty have been quite different among pastoralists used to moving and responding to changing environmental and market conditions, compared to people living in a settled, urban setting, where provision of services was expected to be predictable and controlled. This may be changing, as the mobilities and precarities of contemporary urban life for many may have rendered experiences more similar. Thus, responding to uncertainty in terms of impending disaster or as opportunity and hope, depends very much on individual perspectives, as shaped by social-cultural contexts.

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As this brief, and necessarily selective, review of different literatures has shown, there are diverse ways of thinking about uncertainty, each framing problems and solutions in different ways. By this point it should be clear that the categories of social, political, cultural, practice-based and individual are not mutually exclusive, and perspectives necessarily intertwine. How then do these perspectives inform responses to uncertainty in different domains? Here again the focus must be illustrative rather than comprehensive.

4. Responding to Uncertainty in Different Domains

In this section, I discuss four cases – finance and banking, critical infrastructures, disease outbreaks, and climate and natural disasters – aiming to probe how uncertainty is thought about and responded to, linking back to the areas of literature discussed above. In each case, there are traditions of management and control that can be contrasted with those that are more open, flexible and experimental. By presenting very diverse examples from such different domains alongside each other, the aim is also to highlight some similar lessons and principles for responding to uncertainties.

4.1. Finance and Banking: Volatility in Market Networks

The financial crash of 2007–8 in banking and finance systems has generated much reflection on what went wrong. How could such contagion spread across the system, resulting in near catastrophic collapse? Surely, the international regulatory systems were designed to prevent such outcomes? Surely, the sophisticated algorithms and models that assessed risk in the system were designed for such a task?

The answers emerging are sobering. The sophisticated market in complex derivatives, spread across a huge number of actors, with limited interaction beyond electronic exchange, and based on voluntary

regulation by major banking finance houses proved immensely unstable (Arinaminpathy *et al*. 2012; Haldane 2012; Battiston *et al*. 2013). Stefano Battiston *et al*. (2016: 10031), for example, show how 'small errors on the knowledge of the network of contracts can lead to large errors in the probability of systemic defaults'; a consequence of the collective dynamics of 'small world' networks (Watts and Strogatz 1998). As mathematical ecology showed decades ago, complexity does not necessarily beget stability (May 1974) – and so it was in banking systems (May *et al*. 2008; May and Arinaminpathy 2010; Haldane 2009a, 2009b, 2010, 2012; Haldane and May 2011; Gai *et al*. 2011; Battiston and Caldarelli 2013; Garnier *et al*. 2013; Elliot *et al*. 2014). Just as in the containment of forest fires, insect pest outbreaks or infectious diseases, there are a number of features that increase network robustness (May *et al*. 2008) and help to avoid systemic risks (Kambhu *et al.* 2007; Beale *et al*. 2011). These include: modularity redundancy in design (such as using firebreaks and movement restrictions), close feedback loops (encouraging communication within networks) and identifying super-spreaders (spotting the nodes that spread contagion the fastest).

In the pre-crash banking system, it was the very complexity of the algorithms and the associated models, co-constructed with the organisation of the banking system, that caused some of the problems, even if practitioners were perfectly aware of the models' limitations (Millo and MacKenzie 2009; Wansleben 2012; MacKenzie and Spears 2014). Running on high-speed computers and servers, resulting in exchanges taking place globally in nano-seconds, meant that no one knew exactly what was going on in real time. Volatility in one part of the network could spread very fast to other parts, as 'evaluation cultures' were unable to cope (MacKenzie and Spears 2014). As Andy Haldane (2009a: 7), Chief Economist at the Bank of England, put it:

> Securitisation increased the dimensionality, and thus complexity, of the financial network. Nodes grew in size and interconnections between them multiplied. The financial cat's-cradle became dense and opaque. As a result, the precise source and location of underlying claims became anyone's guess. Follow-the-leader became blind-man's buff. In short, diversification strategies by individual firms generated heightened uncertainty across the system as a whole.

Thus, increasing complexity and decreasing diversity meant that the financial network became more fragile. Points in a network can act as absorbers or amplifiers of shocks, depending on the configuration. In the case of the contagion that spread during the financial crisis, certain nodes became major amplifiers. This was also added to, as risk was profitable: 'escalating leverage, increased trading portfolios and the design of tail-heavy financial instruments' were all key elements (Haldane 2010: 9).

The financial crisis, Haldane (2010: 12) argues, was rooted in 'an exaggerated sense of knowledge and control'. He notes, 'Risks and counterparty relationships outstripped banks' ability to manage them. Servers outpaced synapses. Large banks grew to comprise several thousand distinct legal entities. When Lehman Brothers failed, it had almost one million open derivatives.'

The implications for regulation are profound. The Basel framework for financial regulation, based on a complex, layered web of risk-based measures was found seriously wanting. Haldane (2012: 19) observes, 'because complexity generates uncertainty, not risk, it requires a regulatory response grounded in simplicity, not complexity'. This, he argues, means rethinking network configurations, and facilitating new practices and behaviours among those involved, requiring new skills to enhance reliability. This suggests a shift from reliance on opaque and highly complex risk-based models to allowing supervisors more discretion and judgement, accepting uncertainty as a subjectively constructed state of knowledge. This requires deliberation among response options in the face of inevitably incomplete information, and encouragement of a bigger picture view, rather than a narrow obsession with tick-box rule compliance. By breaking up the network into more modular units, human relationships and interactions can be encouraged and sustained and wider crises spotted.

Ethnographic studies of banks, trading floors and financial analysts have shown how, despite the systemic failures of network organisation and regulation, key actors responded (Wansleben 2012, 2014; Leins 2018). After all, the crisis did not result in a wholesale collapse (Grabel 2018). Networks among actors are vital, as is the performative dimension in the way that models, practices and responses are constructed (Callon 2009; MacKenzie 2008, 2009). Here, rules-of-thumb, practical heuristics, imagination and experimentation were all key (Akerlof and Shiller 2010; Tuckett 2018).

The practical, adaptive responses of financial regulators, supervisors and traders are seen in hindsight to be essential factors in avoiding even more damage (Grabel 2018). This means the encouragement of 'productive incoherence' and pragmatic innovation in financial systems (Grabel 2010), along with a challenge of analytical monocultures, entrenched mental models and group-based emotions and behaviours (Bronk and Jacoby 2016).

The experience of the financial crisis suggests some major challenges to thinking and practice in economics and finance, however. Since the 1950s, mainstream economic frameworks have all assumed that future risks are known, or predictable. For example, finance economists argued that risk could be calculated and securitised and that portfolio risks could be measured, priced and hedged (Rubinstein 1974; Merton 1969). Economic actors, in turn, showed rational expectations in contexts of complete knowledge, and economies functioned according to models of general equilibrium (Haldane 2012). But these are strong assumptions, embedded in elegant models and linked to politically expedient policy recommendations. However, as discussed earlier, older traditions of macroeconomics – 'from Keynes to Hayek and from Simon to Friedman' – have long questioned such assumptions. In such perspectives, coming from very different political stances, imperfections in information and knowledge, and so an emphasis on subjective constructions of uncertainty, are seen to be central (Haldane 2012: 2).

Lessons from the financial crisis reinforce the idea, following Karl Polanyi (1944) and many others, that economies are always embedded, and understanding and responding to uncertainty must reflect this (Beckert 1996, 2007; Evans 2009). New perspectives in economic thinking and practice are today fundamentally challenging mainstream approaches. These are exploring, for example, network topologies and dynamics (Anand *et al.* 2012), emotion and imagination (Beckert 2015; Tuckett 2011), narratives and storytelling (Beckert and Bronk 2016) and co-evolution, adaptive management and innovation (Rammel *et al.* 2007).

Such approaches all make perspectives on uncertainty central, and all suggest a more grounded, interdisciplinary approach to economics and finance, rejecting the reliance on arcane, opaque or overly simplified models of risk and control.

4.2. Critical Infrastructures: Generating Reliability

In the context of critical infrastructures discussed above, reliability emerges when there is the safe and continuous provision of the service. Such services may be, for example, water, electricity, natural gas or telecommunications. Each is subject to uncertain stresses and shocks – for instance, volatile demand, sudden system failures, and natural hazards affecting the system as a whole. As a result, managers of such systems must deal with risk and uncertainty continuously.

The engineering response is to develop a series of design protocols that ensure services are offered without disruption, based on the modelling of event scenarios, predicted as regular or as a once-in-a-decade occurrence. These systems are centred squarely on risk management and emergency planning. Highly trained engineers will be on call to fix problems when they arise, even if some level of redundancy is incorporated in the system. This risk analysis and management approach is the standard response but, beyond the protocols, procedures and regulations, there are other things going on.

Those studying critical infrastructures in practice (not just by design) have observed a set of other practices and behaviours. Accidents will always happen; they are 'normal', as Charles Perrow (1984/2011) argues. He shows how catastrophic accidents are more likely in tightly coupled complex systems, where complexity overwhelms adaptive flexibility. Whether in respect of oil platforms, systems of aircraft navigation or nuclear power plants, unnecessarily complex control systems can often result in failure. Better to have in-built redundancy, flexibility, the ability to adapt and learn than a supposedly fool-proof engineered system, which will almost inevitably fail at some point.

Those studying critical infrastructures argue that reliability is generated through proactive intervention, not passive coping. This is undertaken by reliability professionals who are skilled at dealing with 'mess' (Roe 2013; 2016). As noted above, it is the knowledge, skills and practices of such professionals that are crucial in assuring the reliable function of critical infrastructure systems, where failure is not acceptable – as in the case of nuclear power plant or air traffic control systems – because they are highly dangerous and dreaded.

How risks and uncertainties are responded to depends on how the system is bounded; in other words, what is being operated, both in the 'control room' and the wider network, linking, by way of example, scientists, engineers, information technology professionals, suppliers, regulators and others, who, together, keep the system running. Responses also depend on the standards to which service provision is expected to perform. This may differ, say, between precluding certain events, avoiding catastrophic collapse, or accepting some inevitable disruption. What reliability is and how it is managed will therefore depend on all these factors.

Reliability management also depends on the level of uncertainty – in the sense of knowledge of likelihoods and outcomes. Avoiding conditions of ignorance is crucial, but experimenting, adapting, and improvising in ways that do not threaten the limits of system survival when conditions are uncertain or ambivalent, reinforces the robustness of response. So, in a control room, reliability (or mess) professionals must assess probabilities of likelihoods and outcomes in real time, and help to navigate towards reliability. Many of these responses are informal, mostly unnoticed, below-the-radar practices, but are crucial to generating reliability (Roe 2013).

Research on electricity systems in California, as well as on other infrastructures, shows how the use of tacit, experiential knowledge, case studies, scenario analysis and pattern-recognition skills, combine with astute vigilance and accumulated experience, held in both individuals and networks (Roe and Schulman 2008, 2016; Pettersen and Schulman 2016). These practices go beyond the macro-design of the policymaker or planner, but also beyond the micro-operations of the 'street-level bureaucrat', since, as discussed earlier, reliability/mess professionals are required to track between these modes. This requires adaptation, customisation, the ability to respond to contingencies and recognising what works from case examples and runs of repeat operations (Roe 2016).

No single individual can undertake all these tasks, so reliability emerges from lateral, mutualistic networks; ones (unlike the failed banking finance networks discussed above) that are linked by personal contact, trust and collegial relationships, and a common understanding of performance regimes that avoid failure and prevent complacency. Not getting lost in the detail of immediate operational concerns, nor disappearing into the big-picture policy frame, the reliability professionals must tack between these frames, learning continuously and spotting problems and responding in real time.

4.3. Disease Outbreaks: Preparedness and Early Warning

When the next major global disease emergency will occur is always uncertain. For this reason, elaborate systems of early warning and preparedness have been developed at national and international levels. The outbreaks of SARS (Severe Acute Respiratory Syndrome), avian influenza, Zika and Ebola reinforced the need for such systems. But are such responses always the best way of addressing such events? Even

if uncertainty is accepted in planning for future scenarios, are such systems effective? How does the construction of an 'emergency' change the way that responses are managed?

Emergencies imply an exceptional event, one where extraordinary measures are required. Rapid response involves the speedy mobilisation of people and resources. The framing around an emergency means that democratic accountabilities no longer apply for the interim and that a technocratic, managerial response must be rolled out at speed for the 'public good'. Whether in health/disease emergencies, or as a result of terrorist attacks or natural disasters, emergency responses have become central to the accepted conduct by state agencies (Calhoun 2010).

Because emergencies are unexpected, responses must operate based on contingency plans often developed through scenario or table-top exercises (Samimian-Darash and Rotem 2018). Such scenarios are very often developed by experts and professionals working with state agencies, and so are framed around scientific-technical interventions. In the case of disease outbreaks, early warning systems spotting – say, of heightened mortalities, unexplained market shifts or sudden movements of people – are frequently linked to 'containment' measures that aim to control the disease 'at source' (cf. Scoones 2010; Leach *et al*. 2010).

Particularly following the SARS and avian influenza outbreaks in the 2000s, significant investments in early warning and rapid responses were made, including the Global Outbreak Alert and Response Network at the World Health Organization (WHO). Responses were linked to a coordinated risk assessment graded into different levels of threat. Early action and 'at source' intervention are seen as imperative to avoid escalation to increasingly stringent measures (McCloskey *et al*. 2014).

Very often a globalised threat discourse is at the centre of justification for investment in systems at international level (Dry and Leach 2010). The potential cascading costs of a disease outbreak emanating from South-east Asia or West Africa, for example, to global trade and rich market economies are used to justify often draconian restrictions on movement, culling of animals or vaccinations of animals or humans. A securitised, medicalised global health response is the result, sometimes envisaging the deployment of the police or the armed services to enforce movement restrictions so as to contain a disease (Elbe 2010; Lock and Nguyen 2018).

Uncertainties about the potential spread and impact of a disease play into this type of response. Epidemiological modelling exercises, using assumptions about the probabilities of spread and the likelihood of mortality, feed into and fuel policy responses and wider media and public apprehension (Leach and Scoones 2013). Taking worst-case scenarios, catastrophic possibilities are envisaged. Memories of past outbreaks and exemplars – notably the 1918 influenza epidemic – feed into the debate. Urgent, rapid action in the face of deep uncertainty – in fact, ignorance – is thus urged, and supported by significant investments of resources (Stirling and Scoones 2009).

The discourse of preparedness in the face of uncertain events has a long pedigree, not confined to health and disease issues. Andrew Lakoff (2007, 2017) traces current approaches in health to Cold War civil contingency and defence responses to assumed threats of Soviet invasion or nuclear attack, which have since become embedded in institutional responses around other emergencies. Public information campaigns reinforcing the threat and the type of responses that citizens are expected to follow are combined with scenario and simulation exercises, overseen by crisis or emergency management committees of key actors and the stockpiling of essential goods. The state, as the protector of citizens against assumed threats, is the central player, backed up by scientific expertise to justify intervention, and a set of technical, managerial and securitised bio-political responses.

Again, the framing in terms of crisis and emergency enables the suspension of the normal rules of democratic control. Preparedness for uncertain crises is thus a state response that supersedes earlier approaches to social protection and welfare, targeted at vulnerable groups or population-wide

insurance techniques for ensuring health and welfare (Lakoff 2007). As a 'post-political' technocratic response (cf. Swyngedouw 2011), risk management techniques – and the whole apparatus of expert-led practices associated with scenarios, simulations and contingency planning – are thereby justified and deployed as part of a 'crisis narrative', resulting in the undermining of democratic processes (Rayner 2003; 2007).

The experience of major disease outbreaks in recent years has questioned the appropriateness of the technocratic, securitised, post-political risk framing of disease outbreak preparedness and response in the global health system. While not denying the value of globally distributed data collection and dissemination along with coordinated early warning and the capacity for preparing for uncertainty events, the way such systems have evolved and continue to do so leaves much to be desired. By framing the problem in terms of risk, rather than uncertainty and ignorance, and presenting events as event-driven crises and emergencies, a particular regime has emerged, pivoting on a set of pathogen-centred technologies of control, that is central to both early action and response. Such approaches, it has been widely shown, do not necessarily generate the most effective results.

Take the experience of the Ebola outbreak in West Africa in 2014–5. Distrust of biomedical and security responses has been widely documented, along with the failure to articulate with local 'cultural logics' and prior experiences of earlier disease episodes, conflict or war (Leach and Hewlett 2010; Wilkinson *et al*. 2017). This resulted in the frequent failure to engage with the practices of, for example, burial ceremonies, where rapid transmission often occurred, nor with the livelihood requirements of movement to markets and across borders. Where a medical and security response would advocate compulsory quarantine, the establishment of treatment centres and the closing of markets and border crossings, these were not compatible with people's lives, even when they recognised the risks at play. In the face of uncertainty, people's reactions were shaped by beliefs and emotions such as fear and dread, but also the acceptance of fate and the inevitability of God's will (Wilkinson *et al*. 2017).

In the end, people's own knowledge and practice shifted the pattern of the West Africa Ebola epidemic, resulting in far fewer deaths than the risk models predicted. As Paul Richards (2016: 156) observes, 'common sense, improvisation, distributed practical knowledge and collective action are invaluable elements in a people's science of infection control'. Such a 'people's science' contrasts starkly with the expert, medicalised knowledge that was the centre of the response in West Africa. People living with diseases (or droughts or any other 'disaster' for that matter) experience them differently to outsider experts and professionals. Sequential learning of unfolding processes, drawing on subjective experience and practice-based responses, are always evident. A key lesson is that engaging with culturally embedded responses to uncertainty is essential, and this requires a much more attentive, lesson-learning approach that acknowledges the entwined social-biological nature of disease and so takes local knowledge and practices as its starting point (cf. Hinchliffe *et al*. 2016; Lock and Nguyen 2018).

4.4. Climate Change, Natural Hazards and Disasters: The Politics of Vulnerability

Uncertainties are central to forecasting future disasters, whether through long-term impacts of climate change or through the impacts of earthquakes, tsunamis, floods or droughts (Thompson and Warburton 1985; Hough 2002; Handmer and Dovers 2013). A hazard-focused assessment, based on climate or seismological modelling, however, is inadequate. Vulnerability to such hazards depends very much on social, political and historical factors (Blaikie *et al.* 2004). In contrast, a political ecology perspective on climate and natural disaster impacts points to questions of class, wealth, race, education, gender, age, occupation and location, as well as a wider historical, political economy, that affects vulnerabilities. Vulnerabilities as such may well emerge from the long-term consequences of marginalisation and discrimination, the result of neoliberalisation, financialisation and histories of colonisation or racial discrimination (Watts and Bohle 1993; Adger 2006; Perreault *et al*. 2015).

The impact of a flood or earthquake depends on where you live, the quality of your housing and your access to resources to escape in time (Butler *et al*. 2017). Responding to uncertainties requires access to assets – material and social – and capabilities, so people can respond effectively and generate safety and security. Such capabilities are unevenly distributed, and only some people are able to respond in this way. Gaining access to the entitlements – in the sense described by Amartya Sen (1984: 497) as 'the set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces' – means attention to institutions as mediators of safe and secure livelihoods (Leach *et al*. 1999).

Institutions are core to thinking about response to risks and uncertainties (Mehta *et al.* 1999; Dequech 2006), and to moving beyond solely an 'external hazards' framing. Douglass North (1991) describes institutions as the rules of the game and organisations as the players. Therefore, by reinforcing norms and facilitating coordination, institutions act to control risks and uncertainties (Douglas 1986b). Institutions and organisations may be very local, associated with social networks within a community, but they may also relate to wider legal, regulatory and policy spaces. They all affect the opportunity for manoeuvre and the nature of vulnerability of different social groups.

Movement is often an important response to uncertain settings, the result of human–environmental interactions, but mobility and migration depend on social, institutional and political conditions, and so are not options available to everyone. Experiences of migration are highly differentiated by class, gender, ethnicity, education and age (Gertel and Hexel 2018). How different people actively produce security in the face of uncertainty must draw on different rules, institutions or wider social relations and structures, so linking livelihood opportunities with people's agency in what Anthony Giddens (1991) describes as a process of 'structuration'.

As with the case of disease preparedness in the previous section, an entire industry exists for 'disaster risk reduction', linked to multiple frameworks for 'resilience', with international agencies and agreements responsible for policy development and implementation. Very often such approaches take a hazard-based approach to managing or otherwise mitigating risk and uncertainty. The probabilities of a particular disaster event are assessed, again making use of often elaborate modelling techniques, and a response system evolves that aims to mitigate or adapt to the risk. The 'ecological approach' to hazards emphasised the array of natural hazards from floods to droughts to earthquakes (Burton *et al*. 1978). Where uncertainties are acknowledged, they are dealt with often through techniques that reduce the analysis to a risk assessment or a set of scenarios that offer a range of defined outcomes.

For example, in the case of earthquakes, the science of seismology is, in the words of Susan Hough (2002), often fruitlessly engaged in 'predicting the unpredictable'. While the International Panel on Climate Change now adds uncertainty bars to estimates of climate impact derived from diverse model arrays (Aven and Renn 2015), more uncertainties have emerged from any downscaling of global or regional models, making any prediction of likely impact difficult (Thornton *et al*. 2014).

Processes of financialisation are also resulting in new approaches to respond to uncertainties, especially through tools such as insurance. Index-based insurance against the impacts of drought are offered to farmers, pastoralists and others as a way of offsetting climate risks (Chantarat *et al*. 2013; Carter *et al*. 2014). Insurance companies pay out when rainfall or some indicator of production goes below a threshold. The result is a system that attempts to 'govern at a distance' via the market and through a set of technologies for assessing impacts and allocating payments; in this way, the approach responds to uncertain events, creating a market in risk, available to some but excluding others (Johnson 2013a, 2013b, 2015; Isakson 2015; Taylor 2016). Such financial products also may be attached to an array of conditionalities when linked to state or donor subsidy, as a particular style of 'resilience building' is promoted (Reeves 2017). This is seen by some as a new 'rule by experts' (da Costa 2013), which can undermine traditional 'moral economy' approaches to managing risk and uncertainty in agrarian systems (Binswanger-Mkhize 2012; Carter *et al.* 2014). As Marcus Taylor (2016: 237) argues, 'Ignoring

the structural and relational dimensions of risk production leads to an overly technical approach to risk management that is wilfully blind to the intersection of risk and social power'.

Reflecting on the Deepwater Horizon oil disaster, Michael Watts (2016) argues that a pervasive commitment to risk management undermined any commitment to a culture of safety. This consequence was driven at the frontier of extraction through a corporate strategy focus on containing risk through technical means; yet practices of secrecy, concealment and rule-breaking were central to daily practice, which exposed the operation to potential disaster. Quoting Foucault, who commented that 'the motto of neoliberalism is "live dangerously"' (Foucault 2008: 66), Watts argues that a combination of aggressive corporate enclosure of resources has been driven by financialised and technological approaches to create a series of manufactured risks and accumulated insecurities – all the direct result of an extension of neoliberal capitalism into new resource frontiers.

Uncertainties, risks, ambiguities and forms of ignorance (see Figure 1) are, in other words, constructed in relation to social, economic and political orders, not just natural ones. It is this intersection between social-political and natural worlds that a political ecology perspective helps us to understand, pointing to the wider structural relations that generate incertitude and condition responses. Without such a perspective, approaches to climate mitigation and adaptation – or responses to disasters more generally – become narrow, managerial and technocratic, and do not identify, let alone address, underlying causes (Pelling 2003, 2010; Taylor 2014; Watts 2015; Nightingale 2018).

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Across the four domains, a number of themes in the literature discussed earlier are evident. Reflections on finance and banking highlight the importance of perspectives on socially and culturally embedded economies, the social dimensions of network relations and the everyday practices of key actors. Practice perspectives are also central to the discussion of generating reliability in critical infrastructures, where everyday actions and lesson-learning are essential. The discussion of disease outbreak response and preparedness highlights issues of governmentality and bio-politics, a theme highlighted again in discussions on disasters, where a focus on social difference and wider structural political features is stressed. All cases therefore draw on elements of political, social, cultural, practice-based and individual framings of risk and uncertainty, and all required a cross-disciplinary approach to understanding. While all cases had resonance with wider framings – for example of a 'risk society' – the empirical particularities required more nuance, and each emphasised the importance of specific contextual understandings.

5. Understanding Uncertainty: Emerging Cross-Cutting Themes

Given this necessarily brief exploration of conceptual literatures and empirical cases, what cross-cutting themes emerge that help us to define the contours of an approach that takes uncertainty seriously, and moves beyond a narrow risk framing? Here I identify four.

5.1. Challenging Notions of Modernity and Progress

Various strands of the literature reflect on our understandings of modernity and progress. Uncertainty is a recurrent theme in ideas such as the 'risk society' and 'reflexive modernisation', where risk and uncertainty are seen to be the defining features of contemporary societies. Similar themes are developed around concepts such as 'liquid modernity' and the idea of 'nomadism', where societies must be understood in relation to rhizomatically connected networks, and the shifting, provisional, improvised and mobile identities of people. These and other theorisations of late-modern, post-industrial 'northern' societies construct a particularised and context-specific challenge to modernist

visions of linear progress based on technocratic 'risk management' and control. As the literature demonstrates, there are of course multiple modernities in different contexts, each responding to new risks and uncertainties.

Expanding our horizon to reflections on non-Western societies, other perspectives come into view. These include alternative notions of non-linear time, different understandings of the material and non-material world, culturally specific routes to coping and response, including alternative repertoires of emotion, desire and spirituality, and contrasting imaginaries for now and for the future. All these analyses suggest that a universalised challenge to control-based, risk approaches is limiting. Simplistic frameworks of stylised behaviours – whether grid/group approaches or typologies of risk perception – mask a more diverse and rich array of understandings and responses that matter; but never all the time in the same way. As the literature reiterates, the ontologies and epistemologies of risk and uncertainty are inevitably embedded in histories, cultures and contexts, a theme repeatedly highlighted by the domain-specific cases.

5.2. Rethinking Expertise

These reflections on societal constructions of 'modernity' and 'progress' in response to risk and uncertainty challenge particular notions of science and evidence, and the practices of experts and administrators. If we don't know likelihoods and outcomes, and even more acutely when we don't even know what we don't know, then conventional, current approaches to planning for the future – and so of course innovation, development and notions of the economy – become even more problematic and misleading. More science, clearer insights, better plans just may not be the result, as discussions of emergency planning and disaster risk management show.

This has long been recognised of course, but in risk analysis the prospect of clear, probabilistic definition based on population statistics was, and is still, held to be the basis for future planning. Health, housing, crime or welfare policies were defined through statistical assessments based on actuarial analysis revealing the likelihood of a spread of outcomes, around which a policy could be devised. Precautionary approaches have emerged in relation to new technologies – whether nuclear facilities or biotechnology – particularly in Europe. A precautionary stance assumes the possibility that a negative outcome exists and can well happen, where measures are taken to prevent this. This suggests a new relationship between science and policy, with new investments in early warning monitoring, appraisal methods and early action policy measures (Harremoës *et al*. 2013). A 'preparedness' approach equally accepts the uncertainty – even ignorance – of future events, but recognises that – at some undefined point – they will likely happen. This means, as discussed earlier, being prepared for the worst, and developing early warning, scenario analyses and crisis responses (Lakoff 2017).

Depending on how uncertainties are defined and how futures are imagined, the relationships among expertise, methods, models and analytical frames shift, adjust and even change. With this, the networks of scientific experts, technocrats and administrators involved are crucial, as earlier discussions of financial networks show. This underscores that different practices and forms of 'governmentality' exist whether the framing is one of risk management, insurance, precautionary policy or crisis preparedness. Acting in an uncertain world (cf. Callon 2009) requires enlisting a range of people and things, whether actuarial tables, emergency protocols or economic, climate or disease models, as discussed earlier in relation to both disease outbreak and climate and disaster response. Dealing with 'mess' and so generating reliability in the face of uncertainty is an active process, operating in real time, and involving a range of often tacit, experiential skills and techniques, as discussed in relation to critical infrastructures above (Roe 2013). In other words, the assumptions for any formal scientific-bureaucratic process of risk management or preparedness planning must be understood to differ significantly from what actually happens, whether the context is avoiding accidents happening within critical infrastructures or the securing of reliable outputs in a dryland pastoral system.

5.3. Taking Social Difference and Political Context Seriously

Risks and uncertainties are experienced by and through different people, depending on who they are, where they live, how rich they are and their abilities to respond to uncertain events, shocks and stresses. This is more than individual or group perceptions, as defined through the 'psychometric paradigm'. For sure, perceptions differ depending on whether the prospect of catastrophe is large or small, or whether people have different individual predispositions towards certain types of event (Pidgeon 2008). But how this is experienced and understood, and what impacts it has, depends much more on underlying structures of vulnerability, affected by history, political economy and social position.

As discussed in relation to a political framing of uncertainty (and emphasised again in the discussion of the political ecology of disasters and climate risk), class, race, gender, age and more are all dimensions that affect whether uncertainties are ones that can be coped with, or indeed turned into affordances. Living with or from uncertainties depends on who you – and others – are. Processes of globalisation, neoliberal restructuring and financialisation processes change these dynamics, creating new patterns of vulnerability and possibility in their wake.

Indeed, such processes 'manufacture' uncertainty, generating new risks, but also possibilities, that are unevenly experienced. As the environmental justice literature makes clear, many environmental risks are experienced substantially more by marginalised poor people, including people of colour, living in exposed locations (Cutter 1995). A focus on capabilities, entitlements and differentiated livelihoods is necessarily an important complement to an emphasis on the construction of risk and uncertainty by different actors through different narratives.

5.4 Rethinking the Governance of Risk and Uncertainty

The discussions so far in this paper clearly have very significant implications for governance. When the future is uncertain, the game has to change. The standard approaches of technocratic, control-oriented planning do not – indeed cannot – work. While this lesson is more widely accepted than before, the myths of control persist. This is after all what the 'rule of experts' (Mitchell 2002) requires. Visions of modernisation and progress, in some important respects, rely on this persistence; otherwise, so the fear has it, anything goes. But the alternative to control is not anarchic chaos; rather it is potentially a more collective, caring, convivial approach (cf. llich 1973; de la Bellacasa 2017). In *The Way of Ignorance*, the novelist, poet and activist farmer, Wendell Berry (2005: ix-x), makes the case for one such approach:

> Because ignorance is… a part of our creaturely definition, we need an appropriate way: a way of ignorance, which is the way of neighborly love, kindness, caution, care, appropriate scale, thrift, good work, right livelihood…The way of ignorance, therefore, is to be careful, to know the limits and the efficacy of our knowledge. It is to be humble and to work on an appropriate scale.

Such an approach requires an attentiveness to context and the ability to keep all manner of dissonance and difference in motion without feeling compelled to come to an immediate decision. This in turn requires deliberation among different unknown options, and a more careful, democratic attention to what different views entail and their implications across different groups of people. In this transformational vision, notions of justice are central, and a more patient, sometimes unruly, bottom-up approach to defining future pathways is essential (Stirling 2015; Scoones *et al*. 2018). Any such approach would embrace uncertainty centrally, and make discussions explicit when unknown likelihoods and outcomes are evident, as they almost always are.

In the previous sections, various 'governance' approaches have been mentioned that accept uncertainty. Adaptive management and polycentric governance, importantly, underscore incremental learning and altering course when new knowledge about socio-ecological system dynamics emerges, as it inevitably does. Navigating towards increased system resilience must involve recognising and using

'windows of opportunity', drawing on novel ideas from different sources, with leadership involving 'the ability to span scales of governance, orchestrate networks, integrate and communicate understanding, and reconcile different problem domains' (Olsson *et al*. 2006: 1).

Similarly, experimentalist approaches to governance, widely seen as important in the European context, suggest the need to test out different options and learn from them, adapting responses (cf. Sabel and Zeitlin 2010). Adaptations, improvisations and experiments may occur at local levels, while, as in the case of Chinese policy processes, an overall direction is given (Schoon 2014; Heilman 2018). Notions of 'guided improvisation' (Ang 2016) or 'conceded informality', along with trial-and-error (Husain 2017), become central to a pragmatic approach to addressing uncertainty and complexity (Ansell and Geyer 2017).

Even such approaches, however, can retain a technocratic, expert-led direction, excluding wider deliberations and unruly challenge under the banner of 'keep it simple!' Depending on how uncertainties are framed, and who is expected to respond to them, the relationships between the state, experts and citizens not only can be quite different, but also must be different, given so much can and does matter across scales of governance. Sadly, many of the projects on adaptive resilience planning (or equivalent) being rolled out across drought-vulnerable areas in Africa, for example, often echo the project-directed approaches that preceded them (cf. Côte and Nightingale 2012; Walsh-Dilley *et al*. 2013; Welsh 2014; Felli 2016; Scott-Smith 2018).

In the same way, adaptive management of ecosystems may accept that uncertainty and learning are important, but may be geared to the ultimate outcomes of previous top-down ecosystem management and conservation projects. Neither the European Union advocating experimentalist approaches for energy policy nor the Chinese state promoting 'directed improvisation' around rangeland policy will allow a more inclusive, deliberative, and so challenging and disruptive, process to emerge that offers routes to defining and responding to uncertainties. In sum, politics matters, and adaptive, experimental governance without democratic politics, can end up similar to earlier expert modes – even when uncertainties are recognised, and are indeed central.

6. Conclusion

So, what to do? As a review of ideas, insights and experiences, this paper is not aimed at providing prescriptions; perhaps, though, some broader implications for action can be drawn out despite the obvious limitations of a survey approach. This conclusion is a first attempt.

One of the most significant conclusions echoes a much-repeated quote from Albert Einstein: 'The problems that exist in the world today,' he argued, 'cannot be solved by the level of thinking that created them.'[3] There clearly has to be a lot of unlearning by key actors in order to take on new ways of thinking and doing required to embrace uncertainty. This includes, as we have seen, rejecting a narrowing down to risk approaches for appraisal; taking history, political economy and social difference seriously when acting upon uncertainty's impacts; and challenging the reversion to technocratic type in new forms of governance, among many others.

Shifting frames and changing practice are not easy, and are very challenging to incumbent institutions, disciplines and professional practices. This is in part because of deeply embedded ways of thinking that have become dominant in Western societies. More recently, these have been exported via neo-

[3] http://www.alberteinsteinsite.com/quotes/einsteinquotes.html

colonialism, aid projects and educational programmes across the world, linked to powerful, hegemonic institutions that replicate particular views and practices.

Underpinned by a Cartesian, mechanical, linear worldview, the rationalist, individualist approach that so dominates a 'risk' framing – and has become central to core policy disciplines, including economics – is of course not the only philosophical perspective available. As we have also seen, there are many lessons to be learned from others, both insiders and outsiders, who have grappled with uncertainty, making use of practical, experiential knowledge. Almost by definition, any all-embracing meta-theory will be elusive. Just as the 'risk society' thesis proved limiting, confined in its grander claims to particular contexts and moments in history, so would any other attempt.

That said, by drawing across contextualised, located experiences, and reflecting on the emerging perspectives elaborated above, we can nevertheless identify some pointers to a more useful way of thinking about uncertainty. This advice and ways forward are not universal and will always vary depending on setting, but a commonality is evident. Based on the cross-cutting themes sketched above, six tentative suggestions for the task ahead are offered below:

- Embracing uncertainty means drawing on diverse knowledges, coming from different sources. Different styles of knowledge-making must be combined for effective responses, which requires a combination of formal and informal, accredited and lay knowledge and experiential and conceptual understandings (Wynne 1996; Agrawal 1995; Scoones and Thompson 1994), where forms of 'citizen science' become important in addressing uncertainties in context through culturally embedded, experiential learning (Irwin 2002; Leach *et al*. 2005).

- When knowledge about the world cannot be easily settled by the imposition of a particular style of expertise, or a probabilistic risk perspective, then knowledge about the future and what to do about it become inevitably more contested. Dissonance, conflict, dissensus and contention are the keywords. Such recognition requires the fostering of practices and institutions that enhance open, inclusive deliberation (Holmes and Scoones 2000), rooted in cooperative, mutualistic and networked relations (Stirling 2019). This is especially important for complex, controversial, 'wicked' problems, where uncertainties take centre-stage, as hierarchical, stratified and competitive social-political orders are frequently poor at responding to diverse uncertainties. The need for flexibility and the appreciation of diverse knowledges, values and views also require both attention and openness to the emotional and affective dimensions in thinking about narratives that provide alternatives (Tuckett 2018; Beckert and Bronk 2018), including creative approaches to visualisation, multi-media engagement and narrative storytelling.

- Diverse people experience and respond to uncertainties differently. The underlying vulnerabilities that generate risks and uncertainties, as well as ambiguities and ignorance, require acknowledgement and assessment of the interplay of class, gender, generation, race, ethnicity, sexuality, occupation, education or location (Ribot 2014; Watts 2016). Such dimensions of difference intersect to influence how uncertainties are experienced subjectively and how responses and opportunities are conditioned. Accepting this complexity affords fresh ways of seeing and differentiating a difficult problem, case by case.

- Governing uncertainty means rejecting the narrowing down to singular solutions. Diversity is the watchword, not harmonisation and convergence (Bronk and Jacoby 2016). The analytic imperative in addressing uncertainty is always: look for the differences that matter. Differentiating means avoiding reduced-form, simplifying crisis narratives – such as 'the global

financial crisis' or stark versions of 'environmental catastrophe' – and instead identifying and encouraging local complexities and contextualised solutions.

- Embracing uncertainty requires a sensitive approach to improvisation and experimentation that offers choice. Key is the question: uncertainty with respect to what? Issues of power and agency inevitably arise, posing the question: governance of what for whom? Too often conventional, modernist solutions advocating resilience-building or adaptive management – notionally responding to complexity and uncertainty – remain directed towards implementing expert-led solutions. A shift in governance thinking and practice is therefore required from creating experimental 'subjects' to facilitating the emergence of experimental 'citizens', who can engage with uncertainties and their implications in context (Evans *et al*. 2016; Stilgoe 2016; Laakso *et al*. 2017; Jones and Whitehead 2018). Empowering citizens with the ability to exercise influence on the form and direction of interventions will therefore help to generate new pathways that embrace uncertainty (Leach *et al*. 2010).

- With diverse sources and origins of knowledge constructing uncertainty, a more open, networked and transdisciplinary approach is required. Here too, differences matter. Transdisciplinarity involves scientists, practitioners, policymakers, activists and others working together on shared problems. Such transdisciplinary processes require confronting diverse framings, addressing conflicts over values and politics, and seeking alternatives collaboratively (Scoones *et al*. 2018; Temper *et al*. 2018; Marshall *et al*. 2018; Charli-Joseph *et al*. 2018). A profession's strengths can also be its blind-spots, such that humility, reflexivity and openness are required for the processes to go beyond instrumental participation (Chilvers 2008; Chilvers and Evans 2009; Chilvers and Kearnes 2015; Dryzek and Pickering 2017).

All of these themes challenge, often in very fundamental ways, the dominant 'risk framing' that has constructed the mainstream view of science, modernity and progressive change. They highlight the importance of taking knowledge politics seriously, viewing uncertainty as subjective, constructed knowledge, contrasting across individuals and groups. They further suggest very different implications across class, gender, race and social difference more broadly. All, in turn, suggest challenges to the practices of democracy that are required to open up and broaden out debates about uncertainty (Stirling 2008a).

6.1. Lessons From 'The Margins'?

This review has arrived at this point from a reflection on a wide range of existing literatures. That said, the sources have been written in English in largely academic formats, even if across diverse academic disciplines and domains of practice. Much of the critical literature is framed around a challenge to modernist thinking and Western notions of progress.

But what if this learning was reversed, and we started not from a critique of established intellectual traditions, but from a more practical, experiential standpoint? Would learning from those who live with, by and from uncertainty – dryland cultivators, fisherfolk, pastoralists, as well as control room operators, trading floor agents and disaster risk managers – result in a different set of perspectives? Would the categorisation of concepts, themes and critiques look the same?

In the PASTRES project, we aim to learn lessons 'from the margins' – in this case pastoral areas in Sardinia, Tibet and northern Kenya – and to link these to wider understandings, exploring dissonances as well as connections. Responding to a naïve outsider's question about uncertainty, a Tibetan herder in the Qinghai region of China reflected: 'the past is gone, the present is happening, but you can't know the future. That is uncertainty (*ngemed*).' Meanwhile, in a discussion with pastoralist elders in northern Kenya, one observed:

> We don't know the future, and what it will bring. Only God can know the future. Our grandfathers made predictions [using animal entrails], but we cannot know. But uncertainties are here now. That's our life! We used to have drought every five years, now it's every two. We are being squeezed by outsiders from all sides.

In both instances, uncertainty was linked to wider understandings of destiny and culturally defined notions of the future, as well as an appreciation of how this influences everyday practices. Equally, the contexts for both the understandings of and the responses to uncertainty were emphasised. Marginalisation through being 'squeezed by outsiders', as well as the consequences of wider economic and environmental change, were all part of the discussions. People with long experience of living with uncertainties articulate a perspective that contrasted with technically defined ideas of risk and uncertainty.

Reflecting on pastoralists' perspectives is not aimed at uncovering a set of somehow pre-modern ideas to be juxtaposed with those of the 'risk society', for example. This is not about transfer or exchange in a conventional sense, where 'indigenous' knowledge becomes 'useful' for others, and can be appropriated and exported. Instead, our aim in the PASTRES project is a more vigilant, attentive and humble appreciation of similarity, yet difference. Can we learn from those often labelled as outsiders to Western norms – pastoralists on the margins, for example – or not recognised by normal organisational theories – such as the control room operators? And do the sometimes unruly, unconventional and improvised perspectives help us to challenge conventional thinking and practice?

As Bruno Latour (2012) argues, 'we have never been modern', and there is much more symmetry in understanding and perspective than is often assumed. Brian Wynne argues (1996) that science has always been 'indeterminate, formulaic and uncertain', and farmers – and other publics – did not trust institutions of uncertainty long before the advent of so-called 'reflexive modernity'. If we have always lived in a 'risk society', then clearly it looks different from different standpoints, and those differences matter profoundly for taking uncertainty seriously.

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About the Author

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Ian works on agrarian and environmental change, particularly in Africa. He has a particular interest in the connections between science, policy and the politics of sustainability. His long-term research on land, agricultural and livelihoods in Zimbabwe is covered in his regular blog, Zimbabweland. He is a member of the editorial collective of the *Journal of Peasant Studies*.

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What is Uncertainty and Why Does it Matter?

STEPS Working Paper 105

Uncertainty defines our times. Whether it is in relation to climate change, disease outbreaks, financial volatility, natural disasters or political settlements, every media headline seems to assert that things are uncertain, and increasingly so. Uncertainty, where we do not know the probabilities of either likelihoods or outcomes, is different to risk, the implications of which are explored in this paper through five different ways of thinking about uncertainty, derived from highly diverse literatures encompassing societal, political, cultural, practice and individual perspectives.

The paper continues by examining how these perspectives relate to four domains: finance and banking; critical infrastructures; disease outbreaks and climate change; natural hazards and disasters. Reflecting on these experiences, the paper argues that embracing uncertainty raises some fundamental challenges. It means questioning simple, linear perspectives on modernity and progress. It means rethinking expertise and including diverse knowledges in deliberations about the future. It means understanding how uncertainties emerge in social, political and economic contexts, and how uncertainties affect different people, depending on class, gender, race, age and other dimensions of social difference. And, if uncertainty is not reducible to probabilistic risk, it means a radically different approach to governance; one that rejects control-oriented, technocratic approaches in favour of more tentative, adaptive, hopeful and caring responses.

The paper concludes by asking whether we can learn from those who live with and from uncertainty – including pastoralists in marginal settings – as part of a wider conversation about embracing uncertainties to meet the challenges of our turbulent world.