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Resilience in practice: Five principles to enable societies to cope with extreme weather events

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ABSTRACT

The concept of resilience is used by many in different ways: as a scientific concept, as a guiding principle, as inspirational 'buzzword', or as a means to become more sustainable. Next to the academic debate on meaning and notions of resilience, the concept has been widely adopted and interpreted in policy contexts, particularly related to climate change and extreme weather events. In addition to having a positive connotation, resilience may cover aspects that are missed in common disaster risk management approaches. Although the precise definition of resilience may remain subject of discussion, the views on what is important to consider in the management of extreme weather events do not differ significantly. Therefore, this paper identifies the key implications of resilience thinking for the management of extreme weather events and translates these into five practical principles for policy making.

1. Introduction

Many policy makers and organisations use resilience as a paradigm or inspirational concept. International agreements in three post-2015 agendas – the Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction, and the Paris Agreement under the United Nations Framework Convention on Climate Change – all call for resilience (Roberts et al., 2015) and many policy documents, such as those from the Asian Development Bank (ADB, 2014), European Union (EU, 2013), Government of the Netherlands (MOIE, 2015) and UK Environment Agency (Dilley, 2016) refer to resilience as something to pursue. Yet, resilience often is more of a buzzword than an operational paradigm (Linkov et al., 2014). At the same time, a large number of more theoretical publications on the meaning of resilience and its relation with concepts such as vulnerability, sustainability, robustness, adaptive capacity and recovery have appeared in the academic literature in the past years (e.g. Davoudi, 2012; Folke, 2006; Pendall et al., 2010; Walker et al., 2004). For policy makers and practitioners it is, however, often not clear how the main notions of resilience thinking translate into practical implementation. Hence, the aim of this paper is making the rather abstract and multi-interpretable resilience concept tangible for policy makers.

The increasing use of the resilience concept in policy documents shows that the concept appeals to policy makers. This is likely not only because resilience has obtained a positive connotation in the policy discourse, but also because it covers significant elements that are missed in approaches to the management of extreme weather event risks that are currently in use (Davoudi, 2012; Linkov et al., 2014; Restemeyer et al., 2015). For instance, disaster risk management approaches, particularly those for extreme weather events, do not explicitly capture the difference between low probability/high consequence events and high probability/low consequence events, nor do they include all consequences, since some are quite difficult to quantify (e.g. indirect damages, reputation loss, costs related to evacuation). Furthermore, risk management approaches that are currently applied often have a sectoral focus and pay limited attention to recovery capacity and recovery rate. At the same time, climate change and changes in society fundamentally challenge conventional risk approaches (Merz et al., 2010a). This is why a wider, more comprehensive approach is needed. The resilience concept may facilitate such an approach.

To support policy makers in meeting their objective of increasing resilience, the academic debate on resilience should be translated into practice. Therefore, we identify the main notions from the scientific resilience debate and translate these into five principles that can be used by policy makers to develop strategies that enhance resilience. We focus on resilience to extreme weather

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events, such as droughts, floods and typhoons, though the five principles could be applied to any disaster risk management problem. The principles will be illustrated with examples and two cases.

2. Resilience

2.1. Defining resilience

Although resilience was already used by physical scientists and ecologists in the 1960s, a paper on the resilience of ecosystems (Holling, 1973) set in motion the development that has become the field of 'resilience science', which studies the linkages between social and natural systems and the dynamics of changes in systems (Davoudi, 2012; Milkoreit et al., 2015).G The meaning and use of resilience has changed over time, though as yet it remains an ambiguous concept that is used in different ways by different people (Béné et al., 2014; Davoudi, 2012; Olsson et al., 2015; Restemeyer et al., 2015; Walker et al., 2004).

Holling (1973) introduced resilience in ecology as the capacity of a system to persist within a domain of attraction in the face of disturbances and changes in state variables, driving variables and parameters. He contrasted persistence, which can imply that a system has multiple 'domains of attraction' or equilibria, with stability, which implies one single equilibrium. Later, Holling (1996) distinguished the two related interpretations of resilience as engineering resilience respectively ecological resilience. Engineering resilience focuses on how fast a system returns to a steady-state after a disturbance and how large the disturbance needs to be before a system is pushed out of its steady-state (i.e. the resistance of the system) (Davoudi, 2012; De Bruijn, 2004; Folke, 2006). Maintaining a function and conservation of an existing situation are elements of engineering resilience. Ecological resilience, on the other hand, does not focus on a single steady-state. It is the ability of a system to cope with disturbances, whilst allowing its natural development and change. Although it also looks at the magnitude of a disturbance that can be coped with by a system without change, once it crosses a threshold the system may change structure and reach a different state (Davoudi, 2012). Ecological resilience is about the functioning of the system, rather than about maintaining a steady-state (Adger, 2000) and reflects the much higher degree of complexity of ecological systems as compared to engineering systems. With the application of the concept of resilience to social systems a third type of resilience emerged: socio-ecological or evolutionary resilience. Socio-ecological resilience implies that a system does not necessarily have one or more equilibrium states, but is adapting and changing continuously (Davoudi, 2012). In addition to persistence, socio-ecological resilience explicitly includes adaptability, which is the capacity of actors in a system to adapt to gradual change, and transformability, which is the capacity to create a fundamentally new system (Folke et al., 2010; Walker et al., 2004). It focuses on the interplay between disturbances, reorganization, sustaining and developing and encompasses adaptive capacity, learning and innovation that humans are capable of.

Next to the rather abstract debate on meaning and definition of resilience, the concept has been adopted and interpreted in many policy contexts. In particular in the contexts of climate change and disaster risk management resilience thinking has spread among interdisciplinary scientists and policy makers. In a policy setting resilience is rarely defined with great precision, but rather used as a versatile term of which the meaning can be adapted to the circumstances (Funfgeld and McEvoy 2012; Pendall et al., 2010). Resilience then becomes an umbrella term for a system property that is good and worth pursuing, but can be interpreted by everyone in its own way. Instead of being an objective system descriptor, resilience becomes a normative concept; a desirable system characteristic (Milkoreit et al., 2015; Olsson et al., 2015). This does not mean that no definitions of resilience are given at all, but rather that they often refer to multiple aspects. For instance, the 100 Resilient Cities Initiative defines urban resilience as "the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience" (www.100resilientcities.org/resilience) and UNISDR (2009 p.24) defines resilience in the context of disaster risk reduction as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions".

In definitions of resilience the threat to which the system should be resilient is often not specified; the focus is on general system characteristics. However, operational definitions are needed when resilience is to be quantified, monitored or addressed by policies (Biggs et al., 2012; De Bruijn 2005; Shaw 2012; Wardekker et al., 2010). In those cases both the system and the relevant disturbance should be clearly specified – "resilience of what to what?" (Carpenter et al., 2001). In addition to enabling the measuring of resilience, those definitions also enable targeting measures to the specific threat and its consequences. For example, if disruptions in power supply limit the resilience of cities, the choice of measures to address this is specific for the kind of threat: for flooding hazards raising power substations could increase resilience, whereas for wind hazards putting cables underground or removing trees next to power lines could be useful. If definitions are used that are not specific regarding the system and disturbance, the focus is usually on generic capabilities which enable societies to cope with damages in some elements, or which facilitate recovery. In the example of power supply this could be to increase redundancy in the network. When resilience is used to analyse human-environment systems two other questions are important: "resilience to what ends?", i.e. what is the purpose or desired outcome of resilience, and "resilience for whom?" (Davoudi, 2012). Increasing resilience is expected to lead to a desirable outcome, but what is desirable in a social context is normative. Similarly, decisions on who should be resilient can involve value judgements about priorities and trade-offs (Berkes and Ross, 2016). For instance, increasing urban flood resilience by measures that affect rural residents need to be negotiated in a political process.

2.2. Main notions of resilience thinking to cope with extreme weather events

Although clear differences exist between definitions of engineering, ecological and socio-ecological resilience, we find that there are also commonalities. Most scientists and policy makers consider resilience as a system property that describes the system's reaction to disturbances and changes and they are concerned with to what degree systems are able to cope with disturbances now and in the future. Although often a return to an equilibrium is mentioned (Davoudi, 2012), i.e. engineering or ecological resilience, the need for adaptation or transition – elements of socio-ecological resilience – are usually also discussed but named differently. There is thus agreement that these elements are also important for the ability to cope with disturbances, not only temporary ones, but also trend-wise changes. Particularly in the area of risk and disaster management for extreme weather events views on what is important to enhance resilience do not differ significantly. This section discusses these main notions of resilience thinking, with a focus on coping with