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Evolutionary resilience and strategies for climate adaptation,

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Abstract

The aim of this paper is to develop a framework by drawing on three broad perspectives on resilience: engineering, ecological, and evolutionary, and to use this framework to critically examine the approach adopted by the draft London's climate change adaptation strategy. The central argument of the paper is that the Strategy's emergency planning-centred approach to climate adaptation veers between a standard ecological understanding of resilience and the more rigid engineering model. Its emphasis is on identifying 'exposure' and 'vulnerability' to risk from climate events and on bouncing back from the consequences of such exposures to a normal state, rather than on the dynamic process of transformation to a more desirable trajectory. The paper concludes that fostering resilience involves planning for not only recovery from shocks, but also cultivating preparedness, and seeking potential transformative opportunities which emerge from change.

1. Introduction

Resilience is a contested concept which is "in danger of becoming a vacuous buzzword" as a result of its "overuse and ambiguity" (Rose, 2007). From its original use in the physical sciences, engineering and ecology, resilience has made its way into a wide range of disciplines including psychology, disaster management, economics, geography, and planning. Over the last decade, it has come into heightened use in policy and practice, where resilience is largely seen as a response to climate change uncertainties and socio-economic insecurities. Building resilience has become a major component of climate adaptation, environmental management, regional economic development, and strategic planning. Despite, or probably because of, this proliferation resilience has remained a fuzzy concept.

This paper aims to develop a conceptual framework for assessing the resilience-building claims in climate adaptation strategies (Section Three) by drawing on the three distinct perspectives on resilience (engineering, ecological, and evolutionary) which are discussed in Davoudi (2012a) (Section Two). This framework is used to critically examine the approach adopted by London's draft (2010) climate change adaptation strategy (Section Four). The main argument is that the Strategy's approach was based on engineering / ecological resilience, but would have benefited from embracing the evolutionary understanding of resilience. The paper concludes (Section Five) by discussing the implications of resilience thinking for climate change adaptation strategies and more broadly, for planning thought and practices. The empirical work in the paper draws on some of the findings from an interdisciplinary research project on 'Adaptation and Resilience in Cities: Analysis and Decision-making using Integrated Assessment', funded by the UK Engineering and Physical Sciences Research Council.¹ A qualitative research method was adopted which included a detailed and systematic review of the Strategy's approach to climate change adaptation based on a risk-by-risk gap analysis (Davoudi *et al.*, 2010) and a series of semi-structured interviews (9 in total) and workshop discussions (6 in total) with key actors and project stakeholders. The various gaps identified in this study are indicative of a broader limitation in the Strategy's resilience concept, which this paper elaborates.

2. The three faces of resilience

Following Davoudi (2012a), the term resilience derives from the Latin word *resilire*, meaning to spring back. So, it is not surprising that resilience is often used to mean the capacity to bounce back or to rebound. Indeed, physical scientists first used the term to

describe the resistance of materials to external shocks. In the 1960s ecologists (Holling, 1961; Morris, 1963; Lewontin, 1969) began to use the term and further develop the concept. The culprit was Crawford Stanley Holling's article in which he explained the distinction between resilience and stability in ecological systems, arguing that "a system can be very resilient and still fluctuate greatly, i.e. have low stability" (Holling, 1973:17). Since then, numerous studies, particularly in the field of ecology, have contributed to resilience thinking. Based on an extensive review of literature from a wide range of disciplines, Davoudi (2012a) distinguishes between three broad conceptualisations of resilience: *engineering*, *ecological* and socio-ecological resilience (Gunderson and Holling, 2002). Following Simmie and Martin (2010), she calls the latter *evolutionary* resilience. These will be elaborated in turn.

From a single equilibrium to multiple equilibria (engineering and ecological resilience)

In his pioneering article that drew the distinction between stability and resilience, Holling suggested that "Stability [...] is the ability of a system to return to an equilibrium state after a temporary disturbance" (Holling, 1973:17). He named this 'domain of stability' engineering resilience (Holling, 1973, 1986). Engineering resilience refers to the ability of a system to return to an equilibrium or steady-state after a disturbance. The emphasis is on return time, "efficiency, constancy and predictability", all of which are deemed essential for optimal engineering design and for making the mathematics tractable (Holling, 1996:33; Gunderson, 2000). A similar static, engineering-based conceptualisation of resilience is also embraced by disaster studies.

Contrasting with stability, Holling suggested that, "Resilience ... is a measure of the ability of these systems to absorb changes [...] and still persist" (Holling, 1973:17). This was later called ecological resilience (Walker *et al.*, 1969; Holling, 1996). It rejects the existence of a single equilibrium and instead suggests that there are multiple equilibria, and that "instabilities can flip a system into another [...] stability domain" (Gunderson, 2000: 426). Ecological resilience thus places the emphasis on persistence, change, and unpredictability, attributes that are embraced by evolutionary biologists. The emphasis is not just on *how long* it takes for the system to bounce back after a disturbance but also, *how much* disturbance it can take and still persist, before changing function. While engineering resilience focuses on maintaining *efficiency* of function, ecological resilience focuses on maintaining *existence* of function (Holling, 1996:33).

Beyond equilibrium (evolutionary resilience)

What engineering and ecological resilience have in common is the notion of a stable equilibrium, "be it a pre-existing [state] to which a resilient system *bounces back* (engineering) or a new [state] to which it *bounces forth* (ecological)" (Davoudi, 2012a: 301). More recently the idea that the nature of the stability domain itself remains fixed over time has been challenged by socio-ecological approaches to resilience (Scheffer, 2009). Socio-ecological resilience argues in favour of "people and nature as interdependent systems" (Folke *et al.*, 2010: 21). Rather than conceiving resilience as "a return to normalcy" (Pendall *et al.* 2010:76), this perspective interprets it as the ability of complex social-ecological systems to change, adapt, or transform in response to stresses and strains (Carpenter *et al.*, 2005). Given the similarities between this view of resilience and the evolutionary perspective, as suggested by Simmie and Martin (2010) in the context of economic geography, Davoudi (2012a) calls this approach *evolutionary* resilience.

The idea is that the structure and functions of systems undergo four distinct phases of change. Holling (1986) calls this the 'adaptive cycle'. Visualising them in the form infinity curves (Figure 1) to represent systems on different scales, it is suggested that the phases include: growth, conservation, creative destruction, and reorganisation

(Gunderson and Holling, 2002). The *growth phase* (r) is characterised by: rapid accumulation of resources (capitals), competition, seizing of opportunities, rising level of diversity and connections, and high but decreasing, resilience. At *conservation phase* (K) growth slows down as resources are stored and used largely for system maintenance. This phase is characterised by: stability, certainty, reduced flexibility, and low resilience. The *creative destruction* phase (Ω) is characterised by chaotic collapse and release of accumulated capital. This is a time of uncertainty when resilience is low but increasing. The *reorganisation phase*, (α), is a time of innovation, restructuring and greatest uncertainty but with high resilience (Pendall *et al.*, 2010:76).



Figure 1: The Adaptive Cycle

Source: adapted from Holling and Gunderson (2002:34-41) and Gunderson (2009:5)

These phases occur in 'panarchical', rather than hierarchical, cycles "which are nested one within each other [sic] across space and time scales" (Holling 2001:396). This implies that firstly, the phases are not necessarily sequential or fixed (i.e. systems may skip a phase and move from r directly to Ω). Secondly, systems function not in a single cycle, but, as depicted in Figure 1, in a series of nested adaptive cycles that operate and interact at multiple scalesⁱⁱ (smaller and larger) and speeds (slow and fast). This is the basis of 'panarchy'ⁱⁱⁱ (Gunderson and Holling, 2002). Thus, in complex adaptive systems there are continual interactions between small and large systems and slow and fast ones. The longer, slower processes operate at a larger scale and the shorter, faster ones occur at smaller scales. By going through the adaptive cycles, they self-organise and maintain resilience. However, if they get stuck in the conservation phase they may become *locked in* and hence more vulnerable to future strains which can disrupt the whole system. The adaptive cycle does not in itself offer a framework for 'measuring' resilience; but rather, it offers an evolutionary understanding of resilience as continually altering, as the system adapts and changes.

3. Resilience as a conceptual framework

The above account confirms Swanstrom's (2008:2) view that, "resilience is more than a metaphor but less than a theory. At best it is a conceptual framework" that helps us think about processes such as climate adaptation in new ways that are more dynamic and holistic. *Evolutionary* resilience broadens the description of resilience "beyond its meaning as a buffer for conserving what you have and recovering to what you were" (Folke *et al.*, 2010: 25), to incorporate the dynamic interplay between persistence,

adaptability and transformability across multiple scales and timeframes in ecological (natural) systems (Davoudi, 2012a drawing on: Holling and Gunderson, 2002; Walker *et al.*, 2004; and Folke *et al.* 2010; see also, Miller *et al.*, 2010; Galderisi *et al.*, 2010). In the social context, this kind of systems thinking may seem overly deterministic, not allowing for human intervention to break the cycle through technologies, ingenuities and foresights. This implies that “the cycle itself as well as changes in resilience may be anticipated and, thus, encouraged or thwarted by systems design and management” (Pendall *et al.*, 2010:78). Therefore, we suggest that in the context of socio-ecological systems, a fourth component should be added to the three mentioned above to reflect the intentionality of human action and intervention. We call it *preparedness* (see also Gunderson, 2009).

Together, this four-dimensional framework (Figure 2) suggests that, in the face of either sudden or slow burning disturbances, complex adaptive socio-ecological systems, such as the City of London, can *become* more or less resilient depending on their social *learning* capacity (being prepared) for enhancing their chances of: resisting disturbances (being persistent and robust), absorbing disturbances without crossing a threshold into an undesirable and possibly irreversible trajectory (being flexible and adaptable), and moving towards a more desirable trajectory (being innovative and transformative).

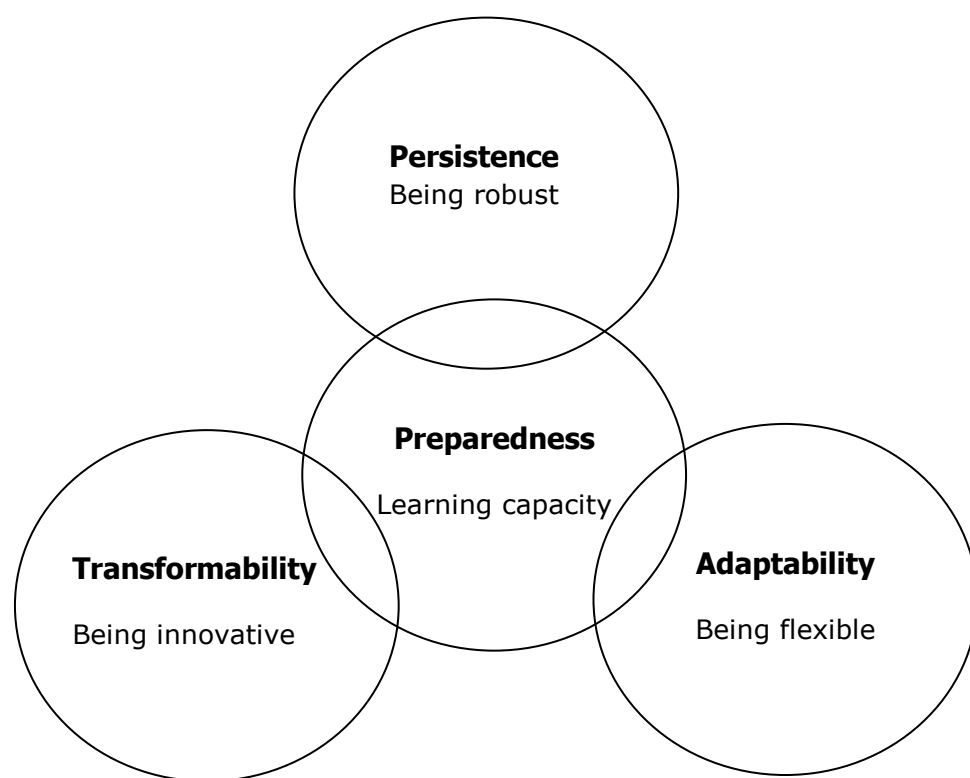


Figure 2: Four-dimensional framework for resilience building

Source: the authors

In the following section we draw on this framework to critically examine the resilience-building strategies in London’s draft climate change adaptation strategy.

4. Draft climate change adaptation strategy for London

In August 2008 the GLA published a ‘London Climate Change Adaptation Strategy’ (LCCAS)^{iv} that set out priorities and actions seen as critical for managing climate related risks (GLA, 2008). A draft for public consultation (from here on referred to as the

'Strategy') was made available for three months in February 2010 (GLA, 2010a) with a timeframe encompassing the period of the 21st century but especially focusing on the years up to 2031.^v "The aim of [...] the Strategy is to assess the consequences of climate change on London and to prepare for the impacts of climate change and extreme weather to protect and enhance the quality of life of Londoners" (GLA, 2010a: 15-16). The term 'prepare' is central in understanding the nature of the document, because the majority of the Strategy's "proposed actions fall under the 'prepare' heading" (ibid.: 19) rather than "actions on the ground" (p.19). The reason for this, according to the Strategy itself (p.19), is the fact that this is the first such strategy and time needs to be invested in developing understanding and capacity to deliver. Hence, the primary aim of the proposed actions is to "increase our understanding of the challenges we face, to ensure that ... we have emergency plans for when extreme weather events occur" (p.7). Most of the proposed actions are thus collaborative, partnership-based interventions. Furthermore, the bulk of the actions (27 out of 34) are related to three defined types of climate change risk (flooding, drought and heatwave) which have been selected from among a slightly wider range of climate risks on the grounds of their relative predictability. The remaining seven actions focus on 'crosscutting' issues of: health, environment, economy and infrastructure.

A roadmap to resilience?

From the resilience perspective cities can be seen as complex, adaptive socio-ecological systems, consisting of internal structures and processes which can be best understood by their self-organisation, emergent properties, non-linear and unpredictable dynamics and patterns of abrupt changes (Costanza *et al.*, 1993). Within this perspective, climate-related events, such as flooding, are considered as external perturbations or disturbances to these systems. Resilience or adaptive capacity is seen as embodied in the *emergent properties* of these socio-ecological systems. This means that resilience is not an asset but a process of change; "not [...] a *being* but [...] a *becoming*" (Davoudi, 2012a: 304). It is a concept that only actually attains performance after the system is confronted with disturbances and stresses. However, unlike other life forms, human beings can make conscious interventions into the process, and through such interventions, planned or otherwise, can diminish, sustain, or enhance resilience. The latter should be the primary aim of any climate adaptation strategy.

Such an aim is implied by the proposals mooted in the London Strategy and encapsulated in a chapter entitled "Roadmap to Resilience" (Chapter 10, p.119). Elsewhere in the document, gaps in climate change planning are identified, and there are other references to actions that can be taken by the "Mayor and partners" and by "Londoners" to "improve resilience" (p.19). Furthermore, the main agency responsible for dealing with adaptation is called the London Resilience Partnership (chaired by the Mayor of London). Despite all this and as our analysis will demonstrate, the approach adopted by the Strategy is different from resilience thinking. One indication of this is that resilience is defined (in an endnote) as the second best outcome after resistance and as a damage reduction action. Thus, the Strategy suggests that, "Flood *resistance* refers to taking measures to make sure that flood water cannot enter a property. Flood *resilience* refers to taking measures to minimise flood damage when a property is flooded and ensure that it can be brought back into full use as quickly as possible" (GLA, 2010a, p.130, emphasis added). This seems a very narrow interpretation of resilience which begs the question: why does the Strategy provide a 'roadmap to resilience' if it is considered as a less desirable outcome than resistance? Our critique of the Strategy is meant neither to undermine the Strategy's pioneering contribution to climate change planning in the UK, nor to deny that it is ahead, in most respects, of other UK regions in its portrayal of a range of climate-related social and ecological, as well as economic risks and consequences. Neither would we wish to diminish the importance of its attempts to map institutional responsibilities and gaps in relation to predictable climate emergencies (see Davoudi *et al.*, 2010). Nevertheless, the shifting, rhetorical use of the term

'resilience' in the Strategy is to some extent an indication of the limited conceptualisation of the nature and purpose of planning for climate change adaptation.

The P2R2 framework

The Draft Strategy "uses the 'Prevent, Prepare, Respond, Recover' framework developed by emergency planners" (p.19) and rooted in disaster risk studies and management practices. The emergency planning model is not prescribed for Climate Change adaptation planning generally, nor as part of the GLA's 'climate change duty', enshrined in the 2007 GLA Act, and it does not structure other regional authorities' adaptation plans. However, the emergency planning approach adopted in the Draft Strategy appears to be connected with local authorities' duty, under the Civil Contingencies Act, 2004 to draw up plans for risks and major emergencies and carry out regular risk assessment. It links with the Emergency Plans that all London Boroughs have to provide and which may either directly cover, or cross reference to, climate risk plans, for example plans for flooding (GLA, 2010a:31). Thus, in conformity with the statutory obligations, there is a tendency for the London Strategy to focus on responses to sudden and extreme climate events rather than on long term, small and incremental changes (which it nevertheless acknowledges). This contrasts with evolutionary resilience which acknowledges that small changes can reverberate through the system and cause large effects, while large alterations may have negligible systemic impacts.

The P2R2 framework (as we call it) is applied to three main climate risks in London: flooding, drought and heatwave, treated largely in isolation from each other. While attempts are made to examine climate impacts on the Strategy's 'crosscutting' issues, it is not clear what happens if several events occur at the same time, as highlighted through our interviews. Although adaptation is defined by the Strategy as "a dynamic process" with "no steady state of being 'adapted'" (p. 17), P2R2 presents a relatively static and linear process that starts with preventative measures and ends with crisis recovery. Such a linear approach, placing its emphasis on the temporal order of interventions, is weak on showing the relative urgency of the various proposed actions and identified gaps. Neither does it acknowledge the interconnection between the phases at multiple scales and time frames. Yet, as one interviewee commented, "the decisions that people are making now are actually the things that are causing the risk [...], the fact that we have built so densely, that we have built across sunny bits of flood plains [...] that we have allowed things to get concreted over, that we use all this energy" (interview, 2009).

Furthermore, the split between the phases and their definitions is sometimes unhelpful as is evident in the application of P2R2 to the three selected risks. A notable example is the 'prevention' phase which is defined as "actions taken to reduce the probability and / or consequences of an impact" (p.19). By contrast, the 'Prepare' phase, which comes second in the sequence, is defined as "actions taken to better understand the risk and opportunities ahead of the change occurring and to proactively enable an effective response and recovery" (p.19). However, measures that are defined as 'preventative' under the Strategy's definition may rather be considered as part of preparation or response. For example, "raising flood defences to prevent flooding" is seen by the Strategy as a preventative measure but it can equally be considered as a response at the time of impact. Similarly, "removing ... development from the flood plain", classed in the Strategy as a preventative action (p.19) can just as well be seen as a preparatory action which aims to identify and manage patterns of vulnerabilities (as discussed below). The fact that actions proposed for one phase can equally belong to another phase is not a trivial matter. It highlights the limitations of the rigid categorisation of actions and its unhelpful linearity, which is in sharp contrast with resilience thinking and its view of cities as interconnected systems with porous boundaries and extensive feedback processes which occur over multiple scales and time frames.

In the following section, we draw on the resilience framework and its four components, developed in section three, to present a critique of the Strategy and its P2R2 approach. Our emphasis is on the Strategy's broad approach rather than its detailed contents and proposed actions which we only draw upon as illustrative examples.

Preparedness

An important characteristic of social systems (in contrast with ecological systems) is humans' capacity for foresight and intentionality (Holling 2001) and their search for ways to enhance their ability to anticipate and plan. "A forest cannot prevent fire or stop climate change. Humans can" (Swanstrom, 2008:18). The nonlinearities and cross-scale interactions of complex systems make them inherently unpredictable. Acknowledging this, however, has not deterred people from finding new technologies and ways of reducing uncertainty. Studies undertaken for understanding the extent and severity of future tidal and fluvial flood risks in London and the capacity of flood barriers and drainage systems to withstand them exemplify such attempts (see particularly the Thames Estuary 2100 Project – Environment Agency, 2009). More challenging still is to foresee the *impact* of such events and the type of 'surprises' which may emerge from those impacts. These inherent uncertainties require a learning-based approach to both accumulation of knowledge and identification of vulnerabilities and opportunities. All are adhered to in the Strategy's 'prepare' stage but with some major limitations, as discussed below. Understanding the probability of events has occupied a large portion of the GLA's time and efforts and the bulk of the Strategy's contents. Major studies and quantitative modelling have been used by the GLA to strengthen the evidence base of the Strategy. Yet, as noted by one interviewee: "policies themselves are good, but they do not necessarily match up as new policies have emerged [...], it's because the pace of the science and understanding has moved in an unprecedented way, that policy is already out of date" (interview, 2009).

By contrast, the Strategy's understanding of consequences and impacts of events is much less informed by evidence. This has led to a lack of prioritisation of the proposed actions. There are other gaps too, such as limited understanding of the patterns of surface water flooding (p.40) or intense local windstorms (p.28). These are acknowledged in the Strategy but a gap which it does not identify is the use of non-coded, experiential knowledge. While past incidence of flooding and heat wave are mentioned along with detailed statistical data about their social, financial and health consequences (and a self-recorded system of flood incidence is promised in Action 4, p.5), there is little mention of past experiences in terms of lessons learnt or peoples' and institutions' coping strategies. Where they are mentioned, communities are mainly viewed as the passive recipients of protective measures, rather than as partners and participants in climate adaptation. There is no acknowledgement of the usefulness of collective memory or personal narrative, both of which are essential for the process of social learning. Cross-scale learning from experiences of one type of risk to another is also rare though promised (See Action 27, P.13).

Identifying potential opportunities as well as vulnerabilities is another critical feature of preparedness. While the bulk of the 34 proposed Actions in the Strategy are of a preparatory nature, only five are related to identifying opportunities (Actions 17,18,19,20,30), viewed narrowly in terms of piecemeal preparation and improvement of the green infrastructure. The rest of the Actions are focused on vulnerabilities. The definition offered in the Strategy for vulnerability tends to frame it more as a descriptor of the individual's circumstances such as "age, health ... proficiency in English... low income" (p.42), and less as an outcome of wider social processes such as social injustices and inequalities. As one interviewee observed: "we are 'packing people in', and they are relying on natural ventilation, yet some of their neighbours are reliant upon air conditioning and dumping the heat on them..." (interview, 2009).

The lack of attention on opportunities epitomises a broader shortcoming of the Strategy and its concern with responding to and recovering from the perceived *negative* consequences of climate-related events. The emphasis on bouncing back as in engineering resilience, or even forth, as in ecological resilience, fails to consider disturbance as a 'window of opportunity' for transforming to a radically different and more desirable trajectory. To increase the likelihood of such transformation, the social learning process should focus as much on detecting potential opportunities as on finding out potential vulnerabilities.

Persistence

An important part of managing climate-related risks is the concern for cities' physical infrastructure and utilities. Their ability to withstand a given level of stress is paramount, particularly during and shortly after a disaster. Short term robustness (understood as rigidity) in this context can be a positive characteristic. However, in the longer recovery timeframe and/or the socio-ecological context it can be a disadvantage. For example, institutional rigidities can stifle adaptability and innovation both in the short and long term. As we mentioned earlier, the P2R2 approach of the London Strategy (in common with the approaches taken by other UK climate adaptation strategies) is rooted in the disaster risk planning tradition and its predominant concern with short-term post-disaster responses. This, coupled with the Strategy's main focus on the physical aspects of the city, may explain its dominant engineering approach to resilience. 'Respond' is defined as "Actions taken in response to an event to limit the impact of the event, for example, restricting non-essential water use during a drought, or providing emergency accommodation for people displaced by an extreme weather event" (p.19). Thus, many of the proposed response actions point to either an array of future 'plans', of which many relate to emergency plans, or to damage reduction measures particularly in relation to the physical fabric of the city. People are mentioned in the Strategy but either as potential victims of climate events, or individual actors who, following some 'awareness raising' campaign and guidance, can become 'resilient' by, for example, "taking out appropriate insurance cover" (p.31); "fit[ting] flood resilient or resistant measures to their homes and buildings" (p.31); "reducing their water consumption" (p.33); or "taking measures ...to cope with heatwaves" (p.34). The reliance on individual strengths and capacities at the expense of building social networks and capitals (discussed below) is another characteristic of the engineering approach to resilience.

Adaptability

Adaptability is at the heart of ecological resilience. As Adger (2003:1) put it, the emphasis is on "the ability to persist and the ability to adapt". While part of adaptability lies in *flexibility*, it also requires *resourcefulness* (discussed below). Some aspects of flexibility and resourcefulness are included in the London Strategy and particularly in the recovery phase (of the P2R2 process) which is defined as "Actions taken after an event to enable a rapid and cost-effective return to normal, or a more sustainable state" (p.19). However, this ecological understanding of resilience is not carried through the Strategy to inform its proposed recovery actions. Furthermore, a number of key features of ecological resilience are missing from the Strategy.

Flexibility refers to the existence of networks and cooperation as pathways to resilience. Some networks facilitate flows of ideas and resources; others enable connections between people and institutions (Janssen *et al.*, 2006). Maintaining links among these networks is one way of increasing the adaptability of socio-ecological systems. There is a growing number of studies which show how social networks have helped post-disaster recovery (e.g. Nelson *et al.*, 2007). Although the London Strategy makes a few references to community plans with regard to flood planning (Action 9, p.36; Action 27, p.70), it does not go into much detail about what these might entail; neither does it pay attention to the role of social networks in the response and recovery phases.

Cooperation across scales and times is another essential factor for adaptability. In ecological contexts, processes that interact across spatial and temporal scales influence systems recovery. For example, Nystrom and Folke (2001) have demonstrated the importance of networks of connectivity across different spatial scales in the recovery of coral reef after hurricanes. The translation of this to socio-ecological systems highlights the significance of the connections between critical sectors (such as transport networks and social networks) as well as the significance of cooperation between various levels of governance in post-disaster recovery. London enjoys a rich network of agencies and institutions with responsibility for climate change. These are linked together through an array of partnerships with overlapping memberships. This is clearly a strength but can also be seen as a weakness, given the disparity of power and responsibilities across multiple tiers of governance and between public, private and voluntary sectors, and the fragility of the partnerships that have been established to connect them together. For example, the recent dismantling of the regional level of governance, including the London Development Agency,^{vi} breaks some important links and cooperative arrangements. In this context, the Strategy's attempt to identify who does what and where the gaps are was a step in the right direction. However, it should be noted that partnership does not necessary lead to effective cooperation. As noted by one interviewee (2009):

I almost see myself as a shepherd sometimes [...] trying to constantly corral these people around and say look [...] there are huge opportunities in this [...], that we are a forum for actually sharing good practice and potentially coming up with projects or incubating projects; but people may not have support for within their own organisation, but it is really even a challenge to try and get them on board. I mean, partnership working in that sense can be quite difficult, when we don't have [...] statutory authority

The Strategy, however, is based on the assumption that the "Mayor will work with ..." (p.7-13) a whole host of other actors and agencies in a somewhat unproblematic way to implement the proposed actions.

Resourcefulness refers to efficiency, rapidity, and diversity. While the Strategy is imbued with concerns over efficiency and rapidity, as demonstrated above, it is not strong on flexibility and diversity. Lack of diversity and the existence of homogenisation were first identified by Holling (1986) as factors contributing to the erosion of resilience. Biological diversity refers to both different types of species and their different functional role (Gunderson, 2009: 8). Economic geographers have long argued that diverse economies are better placed in addressing the adverse consequences of shifting macroeconomic structures (Pendall *et al.*, 2010). Planners contend that mixed-use developments have a better chance of avoiding blight. In the context of climate adaptation, the over-dependence of London's economy on financial services and their clustering in a flood sensitive area reduces London's resilience to climate-related events. However, the need to introduce diversity in the system over a long period of time, through for example spatial planning, is not mentioned in the Strategy, despite the fact that an entire chapter is dedicated to 'London's Economy'.

Transformability

Transformability is what distinguishes evolutionary resilience from engineering and ecological resilience. Transformability considers disturbances to systems as an 'omega' phase of creative destruction (when the system experiences a 'regime shift' and crosses thresholds at different scales), followed rapidly by an 'alpha' phase of renewal and reorganisation leading to unpredictable trajectories. This is a volatile and uncertain process of transformation where the system shifts to something entirely new: desirable or undesirable. In ecological systems, there seems to be little that can be done to steer

such transformation. In socio-ecological systems, however, human ingenuity and intentionality mean that something can be done. This is if the omega phase of the adaptive cycle is framed as a window of opportunity with potentials to transform socio-ecological processes towards radically different and more desirable paths, without underestimating the politics and power involved in determining what is 'desirable' (Davoudi, 2012a and discussed below). There is a growing divergence of opinions regarding whether climate change may be seen as just such a case. Seeing beyond the negative consequences of potential climate-related destruction and putting into place measures that can turn the destruction into renewal requires a high degree of imagination, creativity and political will. The likelihood of such an outcome emerging through social learning processes is vastly increased if society is fully engaged in those processes. After all, adapting to climate change is not just a technical or environmental challenge, "but a social, political and normative challenge", as highlighted by the Royal Commission on Environmental Pollution (RCEP, 2010: 109).

The transformative potential of climate change is hardly evident in the London Strategy, which offers only brief glimpses of a future beyond its proposed emergency planning interventions. The Strategy's dominant engineering understanding of resilience which frames recovery as a return to normality, with an over-emphasis on the physical continuity of the city, is reflected in the following striking statement that, "once a drought is over there is no need for a recovery programme..." (p.33); and, "once a heatwave is over, there is little need to recover as there are few lasting effects" (p.34). Only "the impacts of flood" are considered to "persist long after the flood has gone and initial emergency funding spent" (p.52). This is unfortunate because the making of adaptation strategies provides an opportunity for engaging with not only researchers, modellers, and officials, but also communities (for a good example of how to do this, see Susskind, 2010). Drawing on their knowledge and experience, mobilising their social capital, and capitalising on their creativity are essential if alternative futures are to be imagined and pursued and actions are to be implemented and publicly accepted. Underlining the Strategy's 'blind spot' in this regard is its lack of adequate consultation. While the Strategy is made available through websites and in different formats, the degree of public consultation on the Strategy appears to be limited to a small paragraph, soliciting public suggestions on four dimensions of the Strategy: its evidence base, the framework, the actions and the key indicators. The Strategy neither invites comment on the civic engagement aspects, nor makes a commitment to a systematic presentation or analysis of responses, but only to use 'best' ideas in the final version^{vii}. As noted by the RCEP (2010, pp.108-9), there may be considerable differences in the effectiveness of public engagement, depending upon whether it is conceived in terms of a one-off event or a "continual social intelligence gathering". There appears to be considerable room for improvement in this aspect of the Strategy. As one interviewee commented: "I think, because it is a new policy area, [...] without [...] external scrutiny, there is a danger that we will go off on the wrong track or we just won't be as ambitious as we should be" (Interview, 2009).

5. Summary and conclusion

Every day we are confronted with events which even dedicated institutions and initiatives fail to anticipate, highlighting the difficulties of predicting from which direction the next challenge will emerge. Resilience is now hailed as a way of responding to these uncertainties. However, the way in which resilience is used and understood is dominated by an emphasis on bouncing back to where we were. This is certainly the approach taken by the London Climate Change Adaptation Strategy. Its implicit view of resilience veers between the ecological and the more rigid engineering interpretation. It seeks resilience largely as persistence, embodied in an enduring physical and institutional infrastructure, and encapsulated in the P2R2 trajectory from preparation to recovery. Persistence is, therefore, viewed as in itself the marker of resilience and more generally as the sign of a well-managed organisation or network. This is in contrast with evolutionary resilience

and its pursuit of building capacity for envisaging and embracing transformation through creativity and imagination at institutional, community and individual levels and through cultivating flexibility, resourcefulness and cooperative networks at various scales. Evolutionary resilience promotes the institutionalisation of awareness of adaptability dynamics as a way of enhancing preparedness and with it, the capacity to influence the direction of future transformations. A crucial consequence of the Strategy's engineering approach is its limited attention to the social processes which can enhance or diminish resilience. The importance of people's memories, stories, networks and cooperative relationships in building resilience has been given little space in the Strategy.

Another significant consequence of the Strategy's narrow interpretation of resilience is the focus on the more predictable types of events and impacts – the crosscutting 'health' theme, for example looks at the possibility of disruptions to the NHS, the spread of pests and diseases and interruptions to the food supply. This has the effect of sidelining less predictable incidents (e.g. windstorms, co-occurring extreme weather events), as well as the potential interactions between impacts in the longer term, along with their attendant transformative opportunities. For example, in a scenario of long-term elevated average temperatures, it is possible to foresee potential negative health impacts, even ghettoisation, of what are currently central business areas due to the density of the built environment and preference for glass-wall structures. At the same time, this raises the possibility of a future enhanced role for more heat-resistant, lower-density city areas.

The capacity to envisage and explore different futures suggested through a fuller examination of outcomes at different temporal and physical scales - with willingness to expose and address the 'information gaps' that emerge *en route* - is an essential part of the preparedness which our model places at the centre of resilience. At the same time, it is clear that such scenario building can be perceived as destabilising and as such, provoking public resistance. Susskind notes these inherent communication challenges in raising climate-related uncertainties in a public context (Susskind, 2010: 223). The only clear way of overcoming such resistance, however, seems to lie in a more routine incorporation of public involvement and 'continual social intelligence gathering' in climate adaptation planning.

The concern to 'manage' the response of a public as yet unaccustomed to climate planning's uncertainties, alongside the current ubiquity of an emergency planning mindset, can go part way to explain why an engineering approach to resilience has predominated in other cities besides London. As Fünfgeld and McEvoy (2012:326) report, other prominent climate adaptation strategies (such as the City of Melbourne) are also "framed as risk management" and understand adaptation as "an end point". From a risk management perspective, radical transformation is considered not as a desirable outcome but as a system failure. Such a perspective underpins some of the 'resilient cities' programmes and policies that are advocated by international organisations such as the World Bank and the United Nations. Evolutionary resilience, however, considers climate adaptation as a continuing process which involves social and institutional learning and transformative potentials. As such it discourages planners from putting the emphasis on rigid and fixed plans and the attempt to command and control space and time (Davoudi, 2012b). Instead, the emphasis is on the ubiquity of change and its inherent uncertainties, which can be a source of creativity. Based on this understanding of resilience, our four-dimensional framework (Figure 2), therefore, demands a more far-sighted and multi-scalar ambition for climate change adaptation strategies and a more inter-active and imaginative planning. It also provides a useful analytical framework for assessing claims to resilience building.

Having said that, we agree with Davoudi's (2012a) cautionary note and in particular the four critical issues which she urged planners to consider when translating resilience from ecology to society. These include: the intentionality of human actions, the outcome or purpose of resilience, the delineation of system boundaries, and questions of power and

politics in defining “resilience from what, to what, and who gets to decide” (Porter and Davoudi, 2012: 331). The latter point is particularly pertinent in the context of planning which is essentially about the politics of place and what *ought to* be done, not just to respond to the challenges we face, but also in order to shape them.

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ⁱⁱ Peterson (2000:328) defines scale as "the resolution and extent of the spatial and temporal frequencies of [...] the structures and processes" which in interaction with each other lead to the emergence of "ecological organisation".

ⁱⁱⁱ Panarchy, named for Pan, the Greek god of nature, refers to "how variables at different scales interact to control the dynamics and trajectories of change in ecological and socio-ecological systems" (Gunderson, 2009:4).

^{iv} The Mayor also has to prepare a Climate Change Mitigation and Energy Strategy to reduce greenhouse gas emissions in London (GLA, 2010b).

^v The Draft adaptation strategy analysed in this paper has since been superseded by a final version published in October 2011 (GLA, 2011). Some of the suggestions in this paper (included in an online working paper published as part of the dissemination for the ARCADIA project - Davoudi *et al.*, 2010) are addressed in the final strategy. But many of the points raised in this paper remain pertinent.

^{vi} The LDA was reduced, in 2010, to one third of its former staff and was abolished on 31st March 2012, with its functions absorbed into the GLA.

^{vii} The dedicated GLA website for the consultation notes 7,000 responses but only a few dozen are made available for each 'risk' theme and prominent in the top-rated string are a dozen or so denying the existence or human origin of climate change (GLA, 2010c).