

The Bellagio Initiative

Briefing Summary

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Resilience: A Literature Review

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We know that there will be crises; the immediate dissemination of the news of any worldwide calamity, as well as the lives of most any human being, have shown us that. These crises often resolve; perhaps naturally, or perhaps with effort and cost. Sometimes they prove to be devastating, plunging a country into chaos, an adult into drug use, or an economy into depression. Such crises are often, but not always, unexpected. Climate change, a bit paradoxically, is expected to bring more of the unexpected.

In order to sustain those things we find most valuable, necessary for human life and flourishing, standard procedure has been to reduce risk, mitigate in anticipation, and bolster the speed and efficacy of crisis response. None of these are *per se* problematic. But they have, as yet, offered no lasting solutions to chronic poverty, or a clear path to sustainability in the face of global warming, population growth, and increased energy demands.

Resilience has, in the past four decades, been a term increasingly employed throughout a number of sciences: psychology and ecology, most prominently. Increasingly one finds it in political science, business administration, sociology, history, disaster planning, urban planning, and international development. The shared use of the term does not, however, imply unified concepts of resilience nor the theories in which it is embedded. Different uses generate different methods, sometimes different methodologies. Evidential or other empirical support can differ between domains of application, even when concepts are broadly shared.

The review centres on three resilience frameworks, of increasing complexity: Engineering Resilience (or 'Common Sense' resilience); Systems Resilience, called Robustness in economics; and Resilience in Complex Adaptive Systems. Although each framework has historical roots in particular disciplines, the frameworks themselves can be applied to any domain: Engineering Resilience is utilised in some child development studies; Systems Resilience is often used in governance and management; and the Complex Adaptive Systems approach has been applied to economics, innovation in technology, history, and urban planning. Thus different frameworks along the spectrum offer a choice of perspective; the acceptability of trade-offs between them, and not subject matter, will ultimately determine which perspective is chosen.

Engineering resilience

Engineered systems, such as bridges, buildings, and infrastructure, are often designed so as to handle large stresses, return to normal, and return quickly, when the stress is removed. At the simplest level, increased resilience implies *bouncing back faster after stress, enduring greater stresses, and being disturbed less by a given amount of stress*. 'Stress' can imply both chronic difficulty or an acute crisis. In this basic sense, to be resilient is to withstand a large disturbance without, in the end, changing, disintegrating, or becoming permanently damaged; to return to normal quickly; and to distort less in the face of such stresses.

A significant limitation with this approach is the idea of 'restoring conditions' or 'returning to normal.' Children in poverty who overcome adversities do not stay the same, but they can still be seen as resilient. Cities subject to

disastrous events that are notably different afterwards can still be seen as resilient. Crises can even generate *increased* resilience to future adversity, though not necessarily.

One part of this is accepting that change in response to adversity is itself normal. Fighting against it, as well, can actually cause a *decrease* in resilience. Try to keep everything the same, and the chance of future catastrophe can actually *increase*.

Systems resilience

If we try to keep everything as fixed as possible – if we aim for Engineering Resilience alone – we may risk not only disrupting normal, but also making a return to anything *like* normal impossible.

There are fixed *functions* that humans either need to survive, or generally want to maintain: food, water, shelter, medical care, communities, cities, and parks, to name a few. In some of the world, the needs are provided for; in others, they are not, but few would deny that providing such needs is a priority. To keep something *functioning*, rather than identical, means that there are interacting parts. To incorporate an understanding of internal change, we need to consider resilience in *systems*.

Fixity has its benefits. It is easy enough to divide everything in this world into self-contained domains, assuming nothing in any other domain changes. We can sometimes understand things pretty well this way: water cycles, migration patterns, and chemical bonding. We can understand them with mathematical models, experiments, case studies, histories, and clinical trials.

Slow changes relate to the how interactions between parts change in times of relative stability; the fast changes are in response to crises. How the fast changes take place – whether the system keeps functioning or breaks down – depends on the slow variables. If we don't pay attention to them, if we only focus on what happens in times of disruption, a stable system can, over time, become quite vulnerable to disintegration.

System interactions often go both ways, not just from a higher-level system (e.g., legal) to a lower-level one (households). An individual's behaviour affects the functioning of their family, which in turn has an impact on them; economic policy and the functioning of the economy both influence each other. Systems are *dynamic*, undergoing constant change. Resilience in these

systems can be defined as *maintaining system function in the event of a disturbance*.

Resilience in complex adaptive systems

If a government collapses, or becomes ineffective, does that mean a community can't be resilient? Clearly the system that includes both has ceased functioning, and a community may very well depend on the government beforehand. But communities can create new systems in response; that is, they are *self-organising*. Such self-organising behaviour can take place at many levels: ecosystem species and interactions can change; they have an *adaptive capacity* in response to crisis, yet still thrive, maintaining function. Such systems are called *complex adaptive systems*, and require a new way of thinking about resilience.

In complex adaptive systems, resilience is best defined as the *ability to withstand, recover from, and reorganise in response to crises*. Function is maintained, but system structure may not be.

Complex adaptive systems also generate new questions: if certain parts or subsystems can fail, which parts do we want to continue to operate? And in the event of which sort of crisis? The simpler systems view obviated both questions, because the resilient system maintains all of its subsystems and interactions between them, and disturbances were of a fixed kind, ones that affected these interactions. But to use resilience in complex adaptive systems, one needs to answer both 'Resilience of what?' and 'Resilience to what?'

The flip side of adaptive capacity is *transformability*: the ability of a part of a complex adaptive system to assume a *new* function. Yet these terms are both relative to how we describe that function. The above example of a state-community system can exemplify this relativism: if the function of this system is to *maintain a reciprocal relationship between state and community services*, then a collapse of the state necessarily indicates transformability, since a necessary component of the function was lost. But if the function is to *provide essential services to individuals*, then a collapse of the state doesn't necessarily mean transformation; self-organising adaptations can replicate its functioning.

When something transforms, from one function to another, we can ask how resilient the *new* function is to disturbance. Ecologists have seen

such switches in ecosystems, where a state ‘flips’ from one resilient system to another; there are *multiple attractors*, two distinct ways of functioning, each of which settles around a distinct equilibrium; often one of them does not serve the human uses towards which the other was put.

Tradeoffs

Engineering resilience is the easiest to put into practice: in response to different conditions, one considers responses to various magnitudes of stress; one measures or looks at history to determine the largest type of shock it can withstand, how quickly it returns, and how much it perturbs or bends. Managing to increase resilience is simple: where one can and desires to change conditions to increase resilience, do so.

Systems require more thought for management. Each level of a system can have a certain structure: in a social system, there are connections between individuals (social networks), and individuals fulfill various, different roles (worker, student). These actors interact with each other. Furthermore, these levels interact with other levels to create feedback mechanisms. One thus needs to understand the system structure, first and foremost. Occasionally, one can give a mathematical model of the system; sometimes these can even generate measures of resilience, and predict changes to resilience based on various contemplated actions. More generally, however, a mathematical model is not available, or it is too difficult to generate useful results (i.e., it is non-linear). In such cases, in parallel with the system properties in designed systems, three key systems properties contribute to its resilience: *Diversity and Redundancy, Modular Networks, and Responsive, Regulatory Feedbacks*.

In complex adaptive systems, it is also important to understand system structure; paying attention to diversity, modularity, and feedbacks is still important. However, self-organisation and novelty means that system structure can change, and in fundamentally unexpected, unpredictable ways. Such is the nature of true novelty: we can only attempt to analyse its effects *after* it has emerged. Resilience can be understood in times of stability – when the system structure is not changing much – but there is no comparison of before or after such change.

Ethical obligations

We have so far assumed that the objectives of resilience building are clear; yet resilience is ultimately value neutral. It should be no surprise that promoting resilience can still generate normative questions about goals and values.

That a forest burns, a business fails, or an innovation or social policy isn’t successful: by risking these events, resilience is promoted over a larger scale. Their failure or destruction seems a reasonable cost to bear in promoting a sustainable forest, market economy, and experimentation, respectively. But when we consider people, alone or within families and communities, immediate ethical obligations may overrule the longer-term, or higher-level, view.

Faced with famine, an epidemic of acutely fatal infectious disease, or a natural disaster, the humanitarian response is geared towards preventing death or permanent disability. Yet to prevent this, one might need to overexploit resources to provide food and shelter, or to use antibiotics in a way that might increase the chance of resistant infections in the future. Until resilience has been built up enough, such difficult choices between present urgency and long-term sustainability still need to be made.

Value conflicts

There is also the question about what one should be building the resilience of. Clearly it is not always desirable; chronic poverty is a highly resilient state. Those excluded from the process of governance may not wish to see current functioning sustained. And, given limited resources, one may have to decide, for instance, whether to promote the resilience of a city or an ecosystem.

Some studies, such as Lebel *et al.* (2006), indicate that building resilience of an ecosystem requires including marginalised groups that use it in management, promoting social justice, and proving accountability at all levels. But to be related is not to be identical: more resilience with respect to social justice may still mean less for the ecosystem. Like natural resources, human resources are limited, and difficult decisions about what we most value, what we most want sustained, must still be faced, and made. One not only needs to answer the questions ‘Resilience of what?’ and ‘Resilience to what?’, but also ‘Resilience for whom?’

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Opportunities

There are numerous opportunities for both using the specific applications on resilience, and the concepts of resilience. However, actual projects or policy based on resilience-frameworks are currently mostly limited to ecosystems and disaster management.

Findings addressing vulnerable populations do have some clear implications for policy: make structural changes that promote existing *strengths* that even those in poverty or vulnerable states can develop. One shouldn't focus exclusively on addressing deficits; sometimes doing so prevents endogenous strengths from developing.

Understanding how a particular system works, especially a multilayered one, allows missing links, or fragile connections, to be spotted. The emphasis on efficiency reduces resilience, as does universal connectivity, and a 'top down' flow of information. Such a view goes against much rhetoric of climate change, and promoting an understanding of the necessity of resilience could have significant political and social impact.

More generally, one can apply basic critical systems design principles to spot ways to maintain any system's function in the event of a crisis:

- Maintain a diversity of mechanisms to provide identical functions.

- Make sure networks (social or otherwise) are modular enough so damage or 'infection' of one portion does not immediately propagate to all others.
- Maintain or establish feedbacks to, in the simplest case, establish fail-safe mechanisms in case of malfunction.

One can maximise efficiency over all of these variables; however, such optimisation assumes full working knowledge of the system. In adaptive systems, such optimisation is often detrimental to the adaptive processes; such processes will be, before some crisis that breaks the current system, serving a redundant or seemingly unnecessary function. Fruitful novelty cannot be predicted or made on demand, but it can be prevented altogether.

Besides these *external* ways to promote resilience, there are also *internal* ways: there is no 'best' solution to a problem, when conditions are likely to change, so a *diversity* of strategies are needed. Secondly, projects should aim to be less dependent on others: one failure should be contained, and not propagate to others.

Lastly, foster innovation by decreasing the rigidities of disciplinary and institutional structures: bring people from a wide variety of backgrounds to address problems, even where they have different aims. Fostering novelty in an organisation setting seems to enjoin one to *ignore* existing institutional norms.

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