Modern Resilience: Moving Without Movement[i]

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Introduction

Since the first scientific use of the term in the 17th Century, resilience has been used by various disciplines to describe how targeted systems respond to shocks and stresses that threaten to alter their original design (Alexander, 2013). This has brought the term into the everyday lexicon in various professions and disciplines in the modern day, yet also complicates matters due to the multitudes of differing perspectives regarding how resilience should be defined. Currently, the study of resilience suffers from limited shared understanding as these different disciplines seek to discuss what resilience means for their line of work – a definition that may not be congruent with the understanding of the term in other disciplines. While such differing perspectives are likely to continue in the foreseeable future, this paper seeks to propose a more common baseline understanding of resilience as well as a systems-driven approach applicable for resilience analysis across the multitude of interested disciplines.

In a general sense, resilience has been used as a metaphor that seeks to describe how systems absorb threats and maintain their inherent structure and behaviour. More specifically, resilience is used as a global state of preparedness, where targeted systems can absorb unexpected and potentially high consequence shocks and stresses (Larkin et al., 2015)

Common usage of resilience causes scholars to infer several principles of what resilience actually means. The first such principle includes the positivity of resilience, or the notion that resilience is an inherently beneficial goal to achieve. The second includes the measurement of resilience by characteristics believed to apply to a given system – effectively driving an inductive approach to resilience thinking (Béné et al., 2012). Lastly, resilience thinking is often viewed in a context-agnostic framework, where principles of resilience can be applied to various situations and cases interchangeably.

However, we argue that this metaphorical approach to resilience has inherent weaknesses that must be addressed in order to better understand and apply resilience thinking to various projects.

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Matching point-by-point based upon discussion above, we argue that a more technical understanding of resilience must:

1) Be theoretically neutral. Resilience can refer to the reinforcement of beneficial or harmful activities or outcomes – making it so that it is not always beneficial to develop resilience for a system (Zellmer & Gunderson, 2009). Nevertheless, stakeholders can place normative value upon reinforcing the resilience of systems with beneficial outcomes and/or reducing the resilience of systems that maintain negative outcomes.
2) Foster and apply systems theory. We argue that resilience is the study of systems, where it is incumbent on the researcher to understand the interaction effects between systems and their relevant sub-systems. This may be described as system panarchy, where, not only a system can move through different phases as well change in one sub-system can have a cascade effect that alters all others. Understanding the consequences and magnitude of such cascade effects is crucial to identify areas where systems may be brittle or resilient (Gunderson & Holling, 2002; Holling, 2001).
3) Adopt a context-driven approach to a targeted system (see Cutter et al., 2008 as a good attempt). Given the review of system interactions from Step 2, a vital element to better understand the interactions of systems and the potential for panarchic effects includes the need to (i) gain a greater understanding of the system's historical behaviour and actions, and (ii) identify the various cultural, psychological, and physical characteristics that can enforce or prevent the institution of resilience. Such context is case-specific, and cannot be derived from a global, context-agnostic review or resilience characteristics.
4) Given the context and drivers of resilience noted above, apply existing ecological, psychological, socio-cultural, and physical (and others depending of the systems at stake) scientific theories to enable the identification and measurement of panarchic effects and determine which sub-systems are resilient, which are brittle, and whether the built-in feedback loops and self-reinforcing factors produce inherently ideal or harmful states of existence. Such discussion must inherently consider the interaction effects of such systems over time, rather than as an instantaneous snapshot.
5) By separating the metaphoric use of resilience from the more technical application of the term, it is possible to clarify the often ambiguous role of stakeholders in defining and informing the inputs and implications of a system's resilience. In the metaphoric usage of the term, stakeholders are requested to do almost everything from defining system risks to make estimations about the weaknesses and the strategy. In the latter, however, stakeholders should be asked to participate in defining the problems and weighting of strategic paths. A central concern here includes the high degree of uncertainty and complexity facing stakeholders in such exercises, where the defining of risks and consideration of resilience strategy is a complicated effort even for subject experts.

The Purpose of Resilience

We define resilience as the capability of a system to recover in the midst of shocks or stresses over time. Recovery implicates multiple interactions between factors, and across scales and sub-systems that are usually unexpected and complex in nature. Given such concerns, resilience differs from traditional methodological approaches of protecting against risk, where these uncertain and complex shocks and stresses that affect targeted systems are inherently outside of the design of the system's intended purpose. As such, preparation for such events contains only limited available guidance, and promoting traditional risk approaches such as bolstering system hardness is prohibitively difficult and excessively expensive. Resilience allows us to take on these concerns within a framework of resource constraints and the need to protect against low probability, high consequence events more recently described as 'black swans.' In other words, resilience is preferred to traditional risk management strategies where a systems-theory of protecting against risk is required, and where the potential risks in question are highly unlikely yet potentially catastrophic in nature.

Some theoretical and empirical implications of the above definition of resilience that have to be taken in consideration, and they seldom are, include:

1. The dimension of "time" is not only important to shorten the recovery phase (Linkov et al., 2014), as an indicator of resilience, but also implies the understanding how the system cope with previous stress and what were the dynamics of those changes.
2. Since a system is dynamic (it changes over time), system stresses can occur throughout the system's development. As such, individual strategies can both augment an individual system's resilience to certain stresses while also increasing the system's brittleness in the face of certain shocks. Given this idea, it is essential to understand that strategies to promote resilience may also make the system brittle or susceptible to collapse.
3. Basic rules of systems theory have to pertain to the basic analysis of the system like feedback loops, interaction effects, panarchy, etc.

Thus, a proper application of the resilience methodology is always conceived as the understating of the specific adaptive cycle of that particular system or systems.

Instruments for Resilience Management

A key component of developing resilience is to understand the inherent function and components of the system in question. As such, no universal or 'one-size-fits-all' approach can adequately cover the complexity and uncertainties facing specific systems – at least not without a thorough consideration of the various subsystems and nested components that are changed in the midst of a shock or stress.

Given this consideration, resilience can only be developed where (i) a context-rich understanding of the targeted system and its relevant sub-systems is established, and the interaction effects that cause one sub-system to influence others noted, and (ii) each sub-system is defined based upon the scientific properties and theories provided by psychology, engineering, biology, and other fields. In simpler terms, resilience can only be developed within systems when a full and scientifically-driven understanding of a system's panarchy is fully described. Without such knowledge of interaction effects and context-driven assessment, it is impossible to gain a full understanding of the different factors and scientific principles that drive a specific system's resilience.

That means that the complexity of a certain system can be defined by a specific and limited number of system rules and dynamics, which are respectively comprised of a small set of variables and processes. The complexity is given by those processes operating at different scales in space and time (Simon, 1974; Holling, 2001).

Taking these points into account, the targeted systems are dynamic, follow a set of partially predicted phases and simple rules, and interact with multiple systems and subsystems with different variables. Such a scale is characterized not only by its non-linearity and complex interaction effects, but also by the complete absence of pre-defined top-down approach.

From the above, one can list the characteristics that shape operationalization and measurement of the resilience analysis:

a) Often within engineering applications, resilience is based upon a determination of a system in a utilitarian perspective by identifying the most critical function(s) of the targeted system. That is an insufficient heuristic since one has to determine not only the function but also the systems(s) scale, its spatial considerations (geographical domain), and how such considerations shift and alter over time. This is central consideration to shape resilience management because, through such considerations, it is possible to isolate both the interconnections with the other systems of the same scale and, more importantly, the sub-systems.
b) The idea of adaptive cycle implies that, as underlined, a given system operates within in a specific moment of its cycle. As such, efforts to bolster system resilience must account for current and future developments related to how such a system may change over time (Allen et al., 2014).
c) All systems are inherently comprised of social and ecological drivers. As such, the essential proprieties of a given system like feedback loops, adaptive cycles, etc. cannot be defined without the mobilization of different variables from ecology, economy and human behaviour.
d) The description of the system, both in terms of its proprieties and in terms of processes connected with the specific disciplinary relevant frameworks, has to be repeated in each studied subsystem. Scholarly literature reinforces the aspect of global preparedness that a system has to acquire in order to be resilient pointing to the component of surprise. Surprise also arrives from the work of the different systems and of the effects that certain variables of a certain system have in the functioning of the others.
e) The system functioning is generally multi-factorial. The scale of those variables and theories are the only system elements that will change in order to be adapted to the scale and pace of the systems at stake.
f) Resilience is always an emergent property of a system but never determined solely by the system. Even in psychological resilience, where one would think that resilience is a propriety of the individual system, the more promising avenues of research stress the fact that the major predictors of the individual resilience are the contextual factors (i.e., social networks, family, housing conditions, etc.) (Ungar, 2012).

Metrics and Criteria for Resilience Management

Normally, the current metrics for resilience management are based upon a diverse set of assumptions and proposals. Resilience as operationalized as a Resilience Index (i.e., checklist of items) is a growing trend in the field, and is driven by the desire to compartmentalize each step of the risk management process (Orencio & Fujii, 2013; Todini, 2000; Sempier et al., 2010; Cutter, 2016) . However as described, the application of these methods are of limited value in the abstract. Specifically, this is due not only to difficulties in defining and contextualizing targeted systems and sub-systems but also due to a lack of specific guidance in the way the variables interact in the system. Furthermore, the connection between the evaluated factors and the final resilience score is often tautological.

These indexes are normally based upon representativeness heuristic (i.e., if a concept represents the metaphorical uses of resilience then it is a god index for it) (Tversky & Kahneman, 1975) and not upon the proprieties of the specific system. For instance, making a system more robust and resilient to certain circumstances can also increase the system's brittleness in the face of other shocks and stresses.

We can measure resilience with criteria that can apply to all systems (cognitive, physical, informative, etc.). In spite of the fact that these criteria are an attempt to be free of the representative heuristics, however, they are not free of shortcomings. Specifically, such efforts are often reductionist in nature due to an attempt to operationalize a system into a small number of criteria – the result of which often promotes limited context by which resilience analysts may understand the complexity and interaction effects of the system and its embedded sub-systems (Davoudi, 2012). Furthermore, they are focused in the normal "resilience cycle" that serves as an extension of the normal "continuous improvement cycles" and, more precisely, in the so-called recovery phase. The shortening of the recovery phase is a consequence of the resilient functioning and should not be the sole focus of the intervention.

In the last 100 years, systemic frameworks have been frequently discussed and promoted by various fields in science and technology development. Such efforts have generally fallen short of a functional definition due to an adherence to the truism 'everything is related with everything' – making it functionally impossible to scientifically characterize the properties of a system. Resilience is at risk of becoming another such failed effort due to a lack of focus on defining and measuring the interaction effects between systems and sub-systems – which otherwise would leave resilience as nothing more than a metaphor for more modern risk management.

To overcome such an obstacle, we advocate for a method of resilience management that adopts a theoretically neutral, context-driven, temporally-derived, and systems-driven approach to apply the method to various disciplines and resilience-building activities worldwide.

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