Resilience and Vulnerability in the Framework of Viability: an illustration with ball-and-cup diagrams

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Abstract

(to be part of the follow-up session to the warm-up workshop "Which formalization of resilience and what for?" to be held in Montpellier on October 8, 2013) This proposes to use stability landscapes, also known as ball-and-cup diagrams, to illustrate what the viability framework brings to the joint definition of resilience and vulnerability in social-ecological systems (SESs). Stability landscapes are generally used to describe the resilience of a system when the states that hold its desirable properties coincide with basins of attraction. The viability framework for resilience was originally developed to overcome two major shortcomings of the use of basins of attraction: 1) it shifts the focus of resilience from the system itself towards its properties of interest, which are represented by state constraints that may not coincide with the potential basins of attraction of the dynamic; and 2) it allows for the incorporation of action policies on the system. We show how the former translates into the setting of thresholds that do not affect the stability landscape, yet casts aside some regions of a basin of attraction as undesirable – e.g. because they are economically unacceptable. We also point out that action policies result in reshaping the stability landscape. Viability theory generalizes the concept of attractor by introducing the viability kernel, defined as the set of states for which there is an action policy that enables the continued respect of the properties. Resilience and vulnerability both are concepts that deal with how SESs fare under the pressure from natural hazards such as environmental changes and extreme events. Such hazards can be depicted by changes in the state of the system, changes in the stability landscape, or both. The viability framework originally focuses on resilience which is defined as the ability to keep or recover the properties of interest by getting back to the viability kernel after an event. The set of states from which the system can keep or recover the property of interest is the resilience basin, a mathematical object which generalizes the notion of basin of attraction since it can be defined in the absence of attractors and in the presence of action policies. Then, we define vulnerability as a measure of the potential harm associated with losing the property, even if the system stays within the resilience basin. Thus, the properties can be vulnerable yet resilient. In that sense, the viability framework can deal with both resilience and vulnerability as complementary concepts, while respecting their respective intuitive meanings. We propose to illustrate the framework using ball-and-cup diagrams extracted from the classic nonlinear dynamics of lake eutrophication. Moreover, the proposed framework and its illustration using stability landscapes are expected to foster discussion on the concepts related to adaptation.

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