Towards a Cross-disciplinary Understanding and Operationalisation of Resilience for Environmental Development[i]

Jochen Schanze[1]

[1]Technische Universität Dresden and Leibniz Institute of Ecological Urban and Regional Development (IOER)

Contact: j.schanze@ioer.de

Keywords: Resilience, Cross-disciplinary, Environmental development, Risk management

Challenges of using resilience for environmental development

Increase of human pressure on the natural environment with resulting environmental change on the one hand and increase of human exposure and vulnerability triggered by societal change on the other hand lead to rising impacts and risks worldwide (e.g. IPCC, 2014; CRED, 2016). Thus, human-environment interrelations are getting more complex with accelerating dynamics and uncertainties and declining predictability. Limitations of analysing and controlling those interrelations max out "so-called precautionary principles" as far as they are based on detailed cause-effect calculations (cf. De Bruijne et al., 2010). Thereby, the meaning of the receptors of environmental threats such as for instance people or properties exposed to weather extremes is growing. Particularly, characteristics and performance of elements or systems at risk with their management and governance come to the fore.

Resilience can be seen as one key concept referring to the performance of subjects, objects and systems under changing boundary conditions as their "environment" in a broader sense. It has already a history in a few science disciplines, mainly in physics, psychology and ecology, and today is gaining interest in numerous fields from their specific views. Environmental development as one comprehensive great challenge of the presence involves some of these fields and hence needs to tackle with a variety of resilience concepts. Moreover, it uses resilience in relation to other concepts such as resistance, adaptability and transformability, which requires differentiation.

Cross-disciplinary conceptualisation of resilience

To conceptualise resilience, the element or system under consideration (and its external stress) has to be determined. For environmental development elements and systems may be structured as follows to represent their scope and characteristics:

[i] This paper is part of the IRGC Resource Guide on Resilience, available at: https://www.irgc.org/risk-governance/resilience/. Please cite like a book chapter including the following information: IRGC (2016). Resource Guide on Resilience. Lausanne: EPFL International Risk Governance Center. *v29-07-2016*

- Element
    - Subject (e.g. human being)
    - Organism (e.g. plant)
    - Object (e.g. brick)
- (Sub-)System
    - Social system (e.g. organisation)
    - Ecological system (e.g. lake ecosystem)
    - Technical system (e.g. building)
- Systems' complex
    - Social systems' complex (e.g. municipality)
    - Ecological systems' complex (e.g. stream network)
    - Technical systems' complex (e.g. infrastructure network)
    - Human-environment systems' complex (e.g. landscape)

Governing these elements and (sub-)systems may also be considered from a resilience perspective, although it regards more to a process (management) embedded in a regime (governance):

- Management and governance
    - Management of actors with their strategy
    - Governance with institutional setting and stakeholders with their networks

Each (sub-)category involves particular disciplines with their resilience concepts. However, interdependencies between these (sub-)categories in the context of environmental development ask for the conceptualisation of resilience in a way that allows for a common basic meaning and – as far as possible – linking to disciplinary specifications. Therefore, the following core definition of resilience is proposed for environmental development based on a systematic literature review: ability of an element or (sub-)system (as well as management strategy and governance regime) to regain characteristic features (maybe undergoing reorganisation; cf. Walker et al., 2006) and to continue development after disturbance (sudden) or change (creeping) of boundary conditions (cf. e.g. Nelson et al., 2007). In other words, resilience can be comprehended as elasticity in accomplishing impacts from (a maximum) external stress with a certain degree of recovery and required time, resources and patterns. The proposed core definition is neither restricted to one of the (sub-)categories nor bound to a discipline and serves as a boundary object for disciplinary specification (cf. Hutter, 2013). It is also focused enough to minimise overlap with related concepts (see below).

Resilience in the proposed understanding is descriptive. Evaluation additionally needs goals and targets. In the context of risk as the interference of hazard (or climatic stress) and vulnerability depending on exposure (cf. UNISDR, 2009), it can be seen as one aspect of vulnerability. Vulnerability, in this case, is determined by value or function, susceptibility and coping capacity (Blanco-Vogt & Schanze, 2014). Coping capacity may be considered as the ability to regain the initial state after external stress and hence largely fits the proposed conceptualisation of resilience.

The above definition also enables differentiation from concepts such as resistance, adaptability and transformability. Resistance may be understood as the strength of an element or (sub-)system to withstand external stress and suits the aforementioned meaning of susceptibility. In contrast, adaptability in a narrow sense can be recognised as the ability of a (sub-)system to (autonomously or consciously) alter its characteristic features (efficiently and fast) to changing circumstances in a sense of (co-)evolution (e.g. Smit & Wandel, 2006). Transformability just as describes the capacity to create a fundamentally new system when boundary conditions make the existing element or (sub-)system untenable (Walker et al., 2006).

Risk management and risk governance in the context of environmental development allow for two additional perspectives on resilience: first, governing the resilience of elements and (sub-)systems at risk, second, the resilience of a management strategy or governance regime (e.g. De Bruijne et al., 2010). In the latter case, resilience may be about the ability to deal with unexpected disturbance or change in addition to the anticipation of the future in the management strategy or the capacity of the governance regime (e.g. Wildavsky, 1991).

Measures and instruments for fostering resilience

Influencing and especially fostering resilience according to the proposed core definition can make use of a wide spectrum of measures and instruments. The measure here is understood as intervention causing effects directly and instrument as intervention triggering mechanisms that lead to effects indirectly. In principle, respective activities in the context of resilience aim at optimising the elasticity of the element and system at risk. They differ from activities dedicated to strengthening or altering the element or system to reduce susceptibility (resistance) or exposure and vulnerability (adaptability, transformability). Added value of resilience is the focus on recovery (and its dynamics). It complements linear strategies of anticipating and strengthening against external stress.

Operationalisation of resilience – Examples proving the cross-disciplinary relevance of the proposed core concept

Empirical description of resilience bears on a wide range of disciplinary methods likewise to the variety of conceptualisations. The demand for using resilience with a common core concept in environmental development similarly requests for linking or adapting disciplinary methods to this common understanding. As follows, two examples from completely different (sub-)categories of elements and systems at risk are briefly explained. To highlight interdependency, both examples refer to flood disaster risks.

Although already known in civil engineering, the meaning of the resilience concept for flood risk reduction is still in its infancy. It is used in the context of (wet-)proofing of constructions such as buildings. In this case, resilience describes the ability of construction to dry or to be dried after it has been inundated and wetted. Operationalisation is based on refurbishment needs for recovering from flood impacts and little remaining damage is considered as an indication of maximum resilience. Therefore, the performance of so-called flood resilience technologies is investigated in water laboratories. Findings are included in water depth-damage functions and simulated in damage models (cf. Golz et al., 2015). Resilience from this view may be distinguished from the resistance of a building, which means the strength to withstand flooding without any impact and recovery.

For risk management strategies resilience has no conventional meaning. A recent study on inter-organisational flood risk management strategies provides a set of resilience aspects with further elaborated indicators (Atanga, 2016). Hereby, resilience is understood as capacity (ability) of key stakeholders to respond to the unexpected course of flood disasters in addition to the expected features of flood risk (ibid.). Operationalisation bears on the following resilience aspects:

omnivorousness, homoeostasis, buffer capacity, response process and structure, response resources and response rate. These resilience aspects according to Wildavsky (1991) are complemented by anticipation aspects, which may be considered as a means of resistance in the aforementioned sense.

The two examples show that there is the possibility of using the proposed core concept of resilience and specifying and operationalising it in a disciplinary context. Basic consistency may contribute to tackling with interdependencies across (sub-)categories and disciplines. Moreover, the examples support the intention of differentiating resilience from related concepts.

Annotated Bibliography

Atanga, R. A. (2016). *Flood risk management strategies and resilience: The capacity of key stakeholders to respond to the unexpected course of flood disasters in the city of Accra, Ghana*. (in press).
Operationalisation of resilience for inter-organisational risk management strategies considering the aforementioned resilience aspects with more detailed indicators and complementing resilience by anticipation.

Blanco-Vogt, A., & Schanze, J. (2014). Conceptual and methodological frameworks for large-scale and high-resolution analysis of the physical flood susceptibility of buildings. *Natural Hazards and Earth System Sciences, 14*, 2105-2117. doi: 10.5194/nhess-14-2105-2014

CRED, UNISDR (2016). *The human cost of weather-related disasters 1995 – 2015*. Retrieved from http://www.unisdr.org/2015/docs/climatechange/COP21_WeatherDisastersReport_2015_FINAL.pdf [accessed 13th April 2016].

De Bruijne, M., Boin, R. A., & van Eeten, M. (2010). Resilience: Exploring the concept and its meanings. In: Comfort, L. K., Boin, A., Demchak, C. C. (eds.), *Designing resilience: Preparing for extreme events*. Pittsburgh, PA, University of Pittsburgh Press, 13-32.
Conceptualisation and operationalisation of resilience as possibility of addressing the unforeseen courses of flood disasters in addition to the anticipated ones

Golz, S., Schinke, R., & Naumann, T. (2015). Assessing the effects of flood resilience technologies on building scale. *Urban Water Journal, 12*(1), 30-43. doi: 10.1080/1573062X.2014.939090
Operationalisation of resilience for buildings from laboratory investigations to damage simulation to describe the physical performance mainly after inundation.

Hutter, G. (2013). Organizing social resilience in the context of natural hazards: a research note. Natural Hazards, 67, 47-60. doi: 10.1007/s11069-010-9705-4
Analysis of organisational studies regarding the notion of social resilience and proposal of a set of seven variables to understand social resilience. It concludes with the plea for empirical work to build a strong theory *that deliberately starts with a frame and without a specific definition of social resilience.*

IPCC (2014). *Climate Change 2014: Impacts, adaptation, and vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, Cambridge University Press.

Nelson, D.R., Adger, W.N., & Brown, K. (2007). Adaptation to environmental change: Contributions of a resilience framework. *The Annual Review of Environment and Resources, 32*, 395-419, doi: 10.1146/annurev.energy.32.051807.090348

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16*(3), 282-292. doi: 10.1016/j.gloenvcha.2006.03.008

UNISDR (2009). *Terminology on disaster risk reduction*. Retrieved from http://www.unisdr.org/we/inform/terminology. [accessed 20th February 2010]

Walker, B., Gunderson, L., Kinzig, A., Folke, C., Carpenter, S., Schultz, L. (2006). A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society, 11*(1), 13.

Wildavsky, A. (1991). *Searching for Safety*. New Brunswick, NJ Transaction Press.