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Disaster-Related Resilience as Ability and Process: A Concept Guiding the Analysis of Response Behavior before, during and after Extreme Events

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Abstract

Extreme weather and climate events research needs concepts to analytically capture processes that describe how extreme they are: depth of impact but mainly also temporal aspects such as length, speed and quality of recovery. This paper analyses resilience as a concept to provide these dimensions. The use of the term resilience proliferates in many contexts and disciplines. Interpretations may overlap or even contradict each other. This paper seeks to make a case for a more nuanced understanding of resilience, including the use of "qualifier adjectives" to emphasize differences. Starting from the original etymological meaning of resilience as "bouncing back" the paper aims an innovative (re)conceptualization to facilitate the practical use of resilience in disaster risk management. It is recommended to distinguish between resilience as ability, being a hazard independent pre-disposition for recovery, and resilience as a process, describing different bouncing back and bouncing forward mechanisms inherent in the different recovery phases. This proposed distinction would enable the assessment of recovery abilities before calamities occur and hence could serve as guide to disaster preparedness programmes. The suggested analysis of resilience as a process would open opportunities to use the concept describing preemptive resilience response (presilience), recovery as bouncing back towards a state preceding the hazard event, as well as progressive resilience (prosilience) as bouncing forward and transition of the disaster recovery phase into adaptation and further development.

Keywords

Resilience Definition, Resilience as Ability and Process, Preemptive

Resilience, Bouncing Back, Progressive Resilience

1. Introduction: What Is Resilience?

Extreme events research on weather and climate needs concepts to analytically capture processes that describe how extreme they are: depth of impact but mainly also temporal aspects such as length, speed and quality of recovery. This paper analyses resilience as a concept to provide these aspects and investigates components of resilience as well as clarifying overlapping definitions. Interdisciplinarity is key in extreme events research, and building bridges between extreme events and societal impacts and the disciplines and concepts attached to both, is important. Since, in addition to the aspects of the extreme event itself, it is also the social response to extremes, which at least determines whether extreme events lead to disasters, or not. This conjunction may become a more pressing topic as climate change extreme events continue to impact societies.

Resilience is a term that has gained cross-disciplinary attention in recent years. It already flourishes in certain disciplines while ever more other disciplines are beginning to discover it [1] [2] [3]. Increasingly the adjective "resilient" can be found in many conference titles, irrespective of the subject of the event. In some fields such as Disaster Risk Reduction (DRR) or Climate Change Adaptation (CCA), its overuse is already debated. This paper aims at analyzing traces of a possible "hiatus" and for signs of a "requiescence" of the term. While the scrutiny of resilience by its terminological fuzziness is not novel, this paper seeks to make a case for a nuanced understanding of resilience, very much in the sense of its original etymological meaning of "bouncing back", or "bouncing forward" [4] in order to facilitate its practical applicability at least in the area of disaster risk preparedness and research. This paper aims at analyzing resilience both as (inherent) ability of potentially hazard impacted referent(s) and as a process dominating the recovery phase once a hazard event hits.

Alexander [5] describes a two millennia long evolution and usage of the term "resilience" across different disciplines and epochs. It also analyzes its rather chaotic contemporary utilization. His paper shows that resilience has risen in a number of disciplines and that its use dates back way beyond often cited "ancestor" lines that start, for instance in the field of DRR, in the 1970s. Earlier usages of the term are not necessarily within strict scientific contexts or within the same disciplines. There is a growing number of papers critical on fuzzy terminology and apparent overuse of the term "resilience". It could have been expected that after the publication of Alexander's paper a certain scientific rigor in the resilience-related terminology and restrain in its indiscriminate use would occur. However, this expectation did not materialize.

On the contrary, resilience or resiliency (the paper by Alexander [5] suggests that the two forms are equivalent), fuzzy as it might be, seemingly did not relinquish its appeal. Irrespective of the multitude of (sometimes even contradictory) definitions and concepts [6] [7] and others which should be counterproductive to its popularity, the term "resilience" is still widely used. The original meaning of the word was changed and the term "has frequently been appropriated" without much thought.

Definitional laxity, which increasingly characterizes resilience, may be helpful to adapt it into new contexts, or, to stimulate interdisciplinary dialogue [8], p. 14. But especially in research aiming to apply the concept of resilience, be it qualitative or quantitative assessments such as risk indices or damage functions, more scientific rigor for narrowing down resilience should be observed. For example, new, aggregated resilience metrics have been developed and are proposed as replacements for risk-based performance assessment [9] [10]. While the proposed metric enables the dynamic change of "resilience" to be monitored and hence contributes to the comprehensive assessment of how a disaster and the recovery unfold, it is different from the resilience metric (time elapsed between the disaster and the achievement of pre-disaster performance level, see also **Figure 1**) as proposed by Hashimoto *et al.* [11] and Duckstein *et al.* [12] for water resources systems. Other well-known resilience definitions like Holling [13] [14] [15] [16] are also different as they emphasize the stability of the system, whereas the Hashimoto *et al.* concept focuses on the rapidity of the recovery without considering whether the system left temporarily its original state (what is expected to occur as consequence of a massive hazard revealing the vulnerability of the referent) or not.

Replacements of risk as an overall term in exchange for resilience have been documented at EU and international level in a variety of fields related to disaster risk [8], for instance, in spatial risk assessments or threat and consequence assessments of risks to critical infrastructures [17]. Béné *et al.* [1] discuss the advantages and drawbacks of the resilience concept for vulnerability reduction and poverty alleviation programs.

2. The Appeal of Resilience and the Cacophony It Has Led to

While some publications underline the appeal of resilience for its positive connotation and suggest a broadening of the use of resilience in an encompassing way covering aspects not limited to "bouncing back" only [4] [5] [18] [19] [20] [21], at the same time also appeals for more operationalization of resilience can be observed [7]. For those following an analytic approach and especially within a more quantitative or engineering approach, the existence of resilience as an "umbrella term" meaning several aspects, overlapping with vulnerability or sustainability or with other frequently used and sometimes rather ill-defined terms, can be frustrating. The prevailing "cacophony" in the definition of resilience is counterproductive to operational use.

The positive attribute of resilience likely contributed to its proposed juxtaposition to vulnerability. Resilience is used with increasing preference in concepts while vulnerability seems increasingly being used for applications only [8]. Resilience, in the context of its original etymological meaning "to bounce back" might be interpreted as one of the abilities (or capacities as termed by other authors, for example, Turner *et al.*, [22] p. 8075) enabling reduction in vulnerability, but certainly does not substitute for resistance, robustness, risk sharing, knowledge and other aspects that may also reduce vulnerability to disasters [18] [20] [21]. By aggregating too many features under the term "resilience" conceptual clarity is lost. Resilience is an important, but by no means unique, ability of the affected system to absorb shocks, resist, buffer, and adapt amongst others. It should rather characterize, with well-chosen and measurable parameters, the ability to bounce back to the pre-disturbance state or to bounce forward and achieve a new, but desirable state [4].

Resilience, if interpreted very strictly in the sense of Hashimoto *et al.* [11] and Duckstein *et al.* [12] (see **Figure 1**), may not even be a factor mitigating vulnerability. Resilience is conceived simply to be measured as the time needed for a recovery. As **Figure 1** depicts, resilience is seen as a process occurring after the exposure of vulnerable referents to the hazard, which is manifested in disaster losses. It is noteworthy that Manyena *et al.* [4] also note that "the resilience and vulnerability paradigms are still locked together and increasingly being treated as if they are one and the same" and argue that this should not be the case. Of course, the general assumption that lower vulnerability is usually followed by a quicker recovery is most likely valid.

The reactive nature of resilience implies that this "response" to a disturbance should be triggered from within the affected system, preferably as self-reaction.

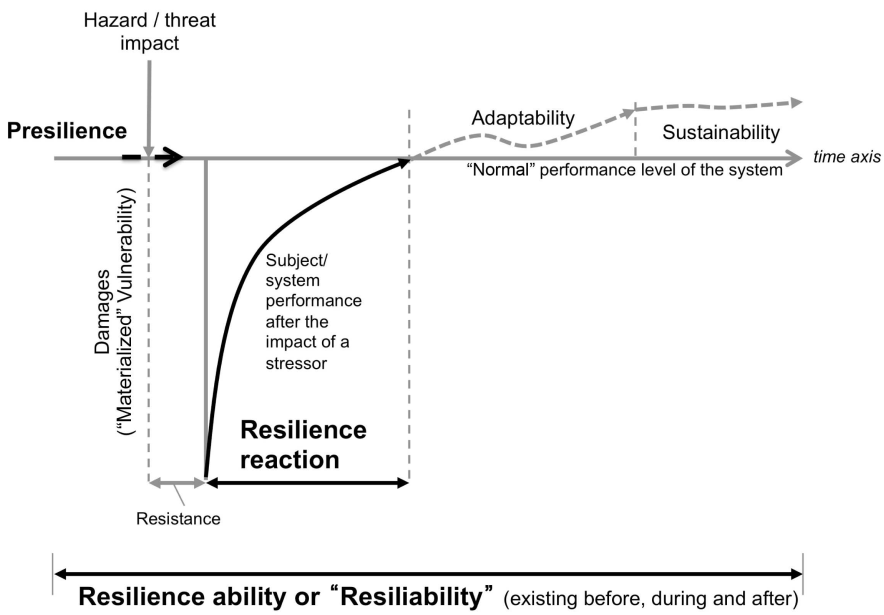

Figure 1. Visualization of the concept of resilience, differentiated into a general resilience ability (resiliability) and the phase of resilience reaction (process) on a time line of an observed system experiencing a hazard or threat impact.

This makes the application of the idea of resilience for ecosystems [13], or to social-ecological systems [23] appealing. For technical systems as long as the mechanical elasticity of the materials involved suffice to compensate the impact, resilience takes place automatically. This can be well observed for example in the case of elasticity during regular operation of railway lines and bridges. Once these material properties are insufficient to trigger automatic resilience, post impact external intervention will be needed to initiate resilience (bouncing back to normal (pre-impact) state. After all, no collapsed bridge can rebuild itself.

3. Resilience and Its Definitions: A Review of the State of the Art

The Publication of the Stockholm Resilience Center [23] "What is resilience? An introduction to social-ecological research" subscribes already in the title to a broad interpretation of resilience.

Shocks and disasters certainly open "windows of opportunity". But can this process be equated with resilience? Isn't it the chance to bounce, or rather jump forward? However, resilience is seen here as an adaptive process, hence cannot be really defined in advance as it reveals itself as a process whereby resilience gets into motion and evolves.

The term resilience is suffering from the relentless efforts of scientists to redefine and to overload it. The "purist" definition of resilience as bouncing back [11] what was called by Holling [15] as "engineering resilience", refers simply to the ability of the system to recover after a disturbance (virtually without extra external help and investment). It could be measured as the time needed to accomplish this bouncing back process based on the inherent elasticity and suppleness of the system. These inherent features or abilities are being exposed to and impacted by the occurrence of hazard event(s).

There are many more different interpretations of resilience exist. In one of the most comprehensive studies Bruneau *et al.* [6] claim that a resilient system shows the following abilities (Page 4 of the Bruneau *et al.* paper):

- Reduced failure probabilities.
- Reduced consequences from failures (expressed in terms of lives lost, damage etc.).
- Reduced time to recovery (to the normal state, preceding the disturbance).

The first entry is de facto the expression of the reliability of the system, or rather the measure of its ability to resist external loads and disturbances without losing its intended functionality. The second entry is capturing what was called by Duckstein *et al.* [12] the magnitude of the vulnerability manifested through the damage extent after the disturbance (or hazard event). In fact, the third item represents the resilience (as used by Hashimoto *et al.*, [11] and Duckstein *et al.* [12]). No doubt that all three aspects are essential to capture and characterize the behavior of the system under stress (disaster) conditions. However, combining de facto three dimensions of the performance metric under one term "resilience" is neither very logical, nor easy to be interpreted. Furthermore, it certainly makes much more difficult to derive a single, physically and monetarily interpretable index for this aggregated three features in one measure called (by Bruneau *et al.* [6]) resilience. The same paper also introduced four "properties" representing resilience:

"*Resilience for both physical and social systems can be further defined as consisting of the following properties*:

Robustness: *strength*, *or the ability of elements*, *systems*, *and other units of analysis to withstand a given level of stress or demand without suffering degradation or loss of function.*

Redundancy: *the extent to which elements*, *systems*, *or other units of analysis exist that are substitutable*, *i.e.*, *capable of satisfying functional requirements in the event of disruption*, *degradation*, *or loss of functionality.*

Resourcefulness: *the capacity to identify problems*, *establish priorities*, *and mobilize resources when conditions exist that threaten to disrupt some element*, *system*, *or other unit of analysis*; *resourcefulness can be further conceptualized as consisting of the ability to apply material* (*i.e.*, *monetary*, *physical*, *technological*, *and informational*) *and human resources to meet established priorities and achieve goals.*

Rapidity: *the capacity to meet priorities and achieve goals in a timely manner in order to contain losses and avoid future disruption*" (*Bruneau et al.* [6], *page* 738).

These "properties" further overload resilience as an "umbrella concept". Robustness and redundancy are eminent features (abilities) of any technical or socioecological system. They enhance safety and security of the system performance, but they rather mitigate the extent of the impact of a stressor than directly contributing to the speed of recovery (which was seen as resilience by Hashimoto *et al.* and Duckstein *et al.*). As redundancy and robustness mitigate the manifested vulnerability the subsequent recovery can of course be shorter due to the reduced amplitude of the perturbation of the system (see **Figure 1**). Resourcefulness and rapidity, as defined by Bruneau *et al.* [6] are clearly virtues (personal abilities) of the managers entrusted to operate the respective systems including the recovery after disturbances and rectifying their consequences. All four "properties" as called by Bruneau *et al.* "help" or serve as basis for resilience but it is claimed here that they are not directly part of it as a process. These four properties: robustness, redundancy, resourcefulness and rapidity, introduced by Bruneau *et al.* [6] resurface, among others, in the publication of Simonovic and Arunkumar [10], however with a somehow different interpretation.

Further in their study Bruneau *et al.* [6] stated that resilience has four dimensions:

"… *resilience can also be conceptualized as encompassing four interrelated dimensions: technical, organizational, social, and economic*".

"*These four dimensions of community resilience*: *technical*, *organization*, *social*, *and economic* (*TOSE*) *cannot be adequately measured by any single meas-*

ure of performance. Instead, different performance measures are required for different systems under analysis. Research is required to address the quantification and measurement of resilience in all its interrelated dimensions"…

These four "dimensions" can be seen as an earlier formulation of what is termed in this paper as "qualifier" adjectives of resilience. Bruneau *et al.* are absolutely right in their warning that these "dimensions" cannot be captured by one single aggregate measure (indicator).

Holling [13] [15], made a clear distinction between ecological resilience and engineering resilience, not to be mixed with yet another term "resilience engineering" [24]. The use of the term ecological resilience is justified to measure the stability of an ecosystem that returns to its original equilibrium state after the impacts of a disturbance. In fact, if an ecosystem cannot recover and flips into a new equilibrium state, it proves its non-resilience; in most cases it still remains an, albeit different, ecosystem. These multiple states of a technical system are usually not foreseen. Once a tipping point is passed the system's functionality might be irrevocably lost. Its engineering resilience can then be characterized by an indefinitely long bouncing back timespan. For example, a reservoir built for storing water for water supply, flood control and energy generation may lose all these functions if the reservoir is completely filled by sediments or debris flow from an upstream landslide.

Folke *et al.* [19] extend the term and concept of resilience into, what they called "resilience thinking". Within this framework they argue for "general resilience" to be juxtaposed with "specified" resiliencies by claiming that the focused specific resiliencies may be traded off against each other. There is some good reason indeed to differentiate between a general resilience and the several potential specified ones but sticking to the same term, frequently even without using the adjective (qualifier) to distinguish scales and meanings the danger of definitional cacophony cannot be ruled out. By introducing a multiple scale resilience, they drew attention to the difficulty inherent in demarcating social-ecological systems. They claim, or better admit, that "the resilience framework broadens the description of resilience beyond its meaning as a buffer for conserving what you have and recovering to what you were". Resilience thinking is described as amalgamating resilience/persistence, adaptability and transformability. While adaptability may be called by some fantasy as "long term" or "slow" resilience or "resilience by learning and changing", transformability was defined as the capacity to cross thresholds into new development trajectories, thus a proactive ability. In light of the definition of ecological resilience (Holling, [13] [15]) transformability may be seen as the ability to shift into a new state. It is then arguable, whether it would still be part of resilience. Finally, it is argued that the state or process that is represented by persistence does not seem to fit under an "umbrella term" resilience. It is not clear why resilience should be used to represent three, otherwise quite clear and distinct processes even if they might happen simultaneously. At this point creating a new term for what the authors call "resilience thinking" would have been warranted rather than adding to resilience yet another, widened meaning.

The paper of Kelman *et al.* [25] does not define either vulnerability or resilience. They rather lament about the overemphasis on quantitative approaches of vulnerability and resilience (V + R). It is however doubtful that this is really the observable trend. Many features of even a very carefully and simply defined 'resilience' are neither adequately nor sufficiently quantified. At least comparisons between different spaces and affected societal groups should be made. The exclusive use of qualitative approaches would jeopardize V + R based prioritization of actions and investments. The big value of V + R would be if they were known-preferably quantitatively-before an extreme event's impact (disaster) occurs. Otherwise the value(s) of V + R if estimated after the events struck would "degrade" from being a diagnosis to a post mortem report on the "pathology" of the disaster. In the section "Conceptual differentiation between resilience as ability and as process" of this paper similarities between vulnerability and resilience (as ability) will be highlighted whereas resilience as process is orthogonal to vulnerability as shown also in **Figure 1**.

Weichselgartner and Kelman's paper [18] provides an excellent summary seen through geographers' eyes. One can agree with most of their statements warning that risk reduction and sustainability frameworks should be used as overarching models rather than using an untested, ill-defined resilience framework. "Quantitative" resilience is not absolute. First and foremost, there is the question to be answered: resilient to what? Their comments resonate well with the key suggestion of this paper, namely that resilience, like vulnerability should be split into a hazard independent core summarizing the resilience abilities and to a hazard dependent resilience process activated (switched on) through exposure of the referent to the hazard impacts.

Excellent short descriptions of emerging resilience frameworks in the UK, USA, OECD and COAG (Council of Australian Governments) and UN-ISDR are presented by Weichselgartner and Kelman [18]. Basically all frameworks are formulated without rigorous definition of the term and without conceptual clarity what is meant by and how to measure resilience. Hence there is no real objective metric to estimate the success of the respective initiative(s). In the UK approach resilience is featured as focusing on 4 components: resistance, reliability, redundancy and response/recovery. Again four "features", but different ones than the proposed ones in Bruneau *et al.* [6]. But why should resilience summarize all four? Can these be measured by an aggregate index? Is it desirable and can it serve as a basis for real world decisions that may focus on any of the above listed components rather than addressing them all simultaneously? For practical use of the concept of resilience the answer is likely to be no, particularly if quantification is attempted.

4. Differentiation of Resilience According to Phases in the Disaster Cycle

The review of the state-of-the art is sobering. Given the present situation, increasing overuse of the term "resilience" does not augur well for its "operationalization". As the first step towards more clarity, the term "resilience" should not be used without certain "resilience qualifiers":

- *Scale qualifiers*: personal, human, community, urban, rural, national etc.-resilience.
- *Context qualifiers*: ecological, engineering, place-based, psychological, system-theoretical, disaster etc.-resilience.
- *Hazard qualifiers*: earthquake resilience, flood resilience, or multi-hazard resilience.

Using such qualifiers in terminology could help avoiding misunderstandings. The use of very generic slogans like "resilient city", which is used more and more even as conference titles are not only incomplete but also misleading. A seismically resilient city could be very non-resilient to flash floods and vice versa. Being more precise in describing the kind of resilience meant and analyzed, for example as a "multi-hazard, urban, engineering resilience approach", could very much facilitate identification and clarity of the discourse. These specifications would help also to counteract what could be called the "dark side of resilience": Corrupt socioeconomic systems have proved to be fairly resilient, irrespective of which definition of resilience is used. Hence any claim of improving resilience should be based on a crisp definition and be cautious of what exactly is made more resilient in the end.

Besides these suggestions for a better description of resilience according to scale, context and hazard the following paragraphs will show that within existing use of resilience definitions there is also an opportunity for conceptual clarification by differentiating resilience according to disaster cycle phases (**Figure 2**) even though the disaster cycle [26] has received much criticism because it points towards a cyclical understanding of disasters as re-occurring in similar ways, while similar measures and situations continue to exist. This does not resemble the ever-changing nature of reality and it also should not normatively suggest a return to the previous state of knowledge or even to build back after a flood disaster at the same place with the same material etc. However, the disaster cycle idea is still very much applied in practice and is also useful for describing the conceptual difference between the phases before, during and after a hazard-induced disaster. Therefore, for the sake of clarity of argumentation, such a simplified depiction of an idealized process path before, during and after a hazard or threat impact will be used throughout this paper. But in order to acknowledge accepted paradigms that have emerged after the panarchy model [27] has been presented, the following **Figure 2** is to show the traditional and conceptually useful disaster cycle as well as a moderated suggestion how to match this with the model of a more dynamic evolving system process that is undulating between different states of temporal stability (termed "adaptive cycle" or "flow of events" between "four system functions" according to Holling [16], see his **Figure 2** for an explanation).

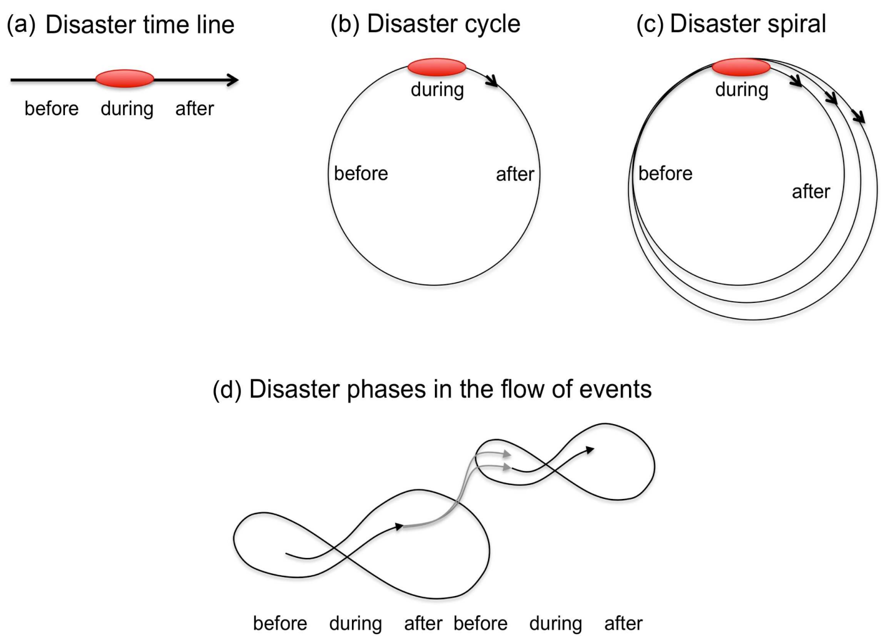

Figure 2. Display of different conceptualizations of disaster phases according to linear time line (a), disaster cycle (b), disaster cycle extended to an evolving spiral (c) and modified to match with adaptive cycle and flow of events (d).

The disaster time line ((a) in **Figure 2**) is a commonly found visualization of disaster phases before, during (red oval) and after a damaging hazard event. The disaster cycle (b) is also commonly used in variations of the terms of prevention, preparation, recovery and mitigation, for instance. These idealized visualizations have received critique on pointing towards a simplified linear (a) or cyclical (b) comprehension of disaster events that, in reality, are much more complex and therefore rather undulating or, not returning to exactly the previous state as before. The spiral representation (c) has therefore been suggested to emphasize a cyclical yet developing model, avoiding an exact "return to the state before". One disaster is unlike the other, with different dimensions and uneven lengths of each phase. The Holling model (d) expresses that also, but adding a continuous stability dynamic to it that might flip from one state of stability to another. This backdrop of awareness of existing models is important to outline for the equally simplified model used later in this paper (**Figure 1**).

Tables 1-3 summarize an attempt to collect, if not all, but at least the most frequently promoted definitions of resilience. Admittedly most of the definitions listed are coming from, or at least related to the disaster resilience literature. This constraint, however, is not counterproductive as this paper focuses on the possible operationalization of resilience in context of hazard-induced disasters. **Tables 1-3** contain an illustrative list of published resilience definitions (emphases in bold by the authors. Sources as provided and taken from resilience definition collections in: [6] [7] [18] [28].

One noteworthy finding in the definitions is that the terms "ability" and "capacity" are very often used, but never specified or differentiated. Another finding

Table 1. Abilities for one phase in the disaster cycle.

Phase of disaster cycle: Resilience as coping, withstanding
"the capacity to cope with unanticipated dangers after they have become manifest, learning to bounce back" Wildavsky 1991, p. 77
"It is the buffer capacity or the ability of a system to absorb perturbation, or the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables." Holling *et al.*, 1995
"Local resiliency with regard to disasters means that a locale is able to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life without a large amount of assistance from outside the community." Miletti, 1999
"the ability of a system to withstand stresses of environmental loading" Bruneau *et al.*, 2003
"Pliability, flexibility, or elasticity to absorb the event. Resiliency is offered by types of construction, barriers, composition of the land (geological base), geography, bomb shelters, location of dwelling, etc. As resiliency increases, so does the absorbing capacity of the society and/or the environment. Resiliency is the inverse of vulnerability." Journ. of Prehospital and Disaster Medicine, 2004
Phase of disaster cycle: Resilience as responding
"Resilience is a fundamental quality of individuals, groups and organisations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behaviour." Horne and Orr 1998, p. 31
"The ability to respond to singular or unique events." Kendra and Wachtendorf, 2003
Phase of disaster cycle: Resilience as adapting/changing
"Resilience is a measure of the recovery time of a system." Correira *et al.*, 1987
"Resilience is the ability of an individual or organisation to expeditiously design and implement positive adaptive behaviours matched to the immediate situation, while enduring minimal stress." Mallak, 1998
"the capacity to adapt existing resources and skills to new situations and operating conditions." Comfort 1999, p. 21
"Resilience is the flip side of vulnerability—a resilient system or population is not sensitive to climate variability and change and has the capacity to adapt." IPCC, 2001
"Resiliency is thought of as a characteristic of systems that offers flexibility and scope for adaptation whilst maintaining certain core functions (for example, access to basic needs and social stability)." Pelling, 2003
"The term implies both the ability to adjust to normal or anticipated levels of stress and to adapt to sudden shocks and extraordinary demands." Bruneau *et al.*, 2003
"The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity, that is, the capacity to change in order to maintain the same identity." Folke *et al.*, 2010

Table 2. Abilities for two phases in the disaster cycle (bold highlighting inserted).

Phase of disaster cycle: Before and during
"Resiliency to disasters means a locale can withstand an extreme natural event with a tolerable level of losses. It takes mitigation actions consistent with achieving that level of protection." Mileti, 1999
Phase of disaster cycle: During and after
"The capacity that people or groups may possess to withstand or recover from emergencies and which can stand as a counterbalance to vulnerability." Buckle, 1998
"The ability to resist downward pressures and to recover from a shock. From the ecology literature: property that allows a system to absorb and use (even benefit from) change. Where resilience is high, it requires a major disturbance to overcome the limits to qualitative change in a system and allow it to be transformed rapidly into another condition. From the sociology literature: ability to exploit opportunities, and resist and recover from negative shocks." Alwang et al., 2001
"The capacity of the damaged ecosystem or community to absorb negative impacts and recover from these." Cardona, 2003
"The ability of an actor to cope with or adapt to hazard stress." Pelling, 2003
"The ability of an organization to absorb the impact of a business interruption, and continue to provide a minimum acceptable level of service." Disaster Recov. Journal, 2005
"The capacity of a system—be it a forest, city or economy—to deal with change and continue to develop; withstanding shocks and disturbances (such as climate change or financial crises) and using such events to catalyze renewal and innovation." Stockholm Resilience Center: Sustainability Science for Biosphere Stewardship: What is Resilience? 2014

is that the definitions can be grouped into those mainly capturing, what is defined as resilience within one, two or more phases of the disaster cycle. This is not a very rigorous assignment and subject to the perspective chosen. However, the definitions found have been grouped whether related to one phase, such as either "stay and endure" (coping, withstanding) during the (immediate) disaster impact or, to the following phase where the system reacts and starts to recover from the impact (adapting, changing). These appear to be the most vital conceptual distinctions. In Figure 1 the first phase is identified as "resistance", which can be related to "coping" and withstanding while already under hazard stress. The second phase is named "resilience" in Figure 1 and relates to the recovery phase after the hazard stress decreases. Resilience is thus preceding the (usually slower) process of adaptation. The use of "adapting" in definitions of resilience as well as using multiple abilities and capacities reflect the usage of resilience as a general feature or, encompassing an even broader transformation ability.

5. Conceptual Differentiation between Resilience as Ability and as Process

Resilience and vulnerability, while different, and frequently juxtaposed, share

Table 3. Abilities for multiple phases in the disaster cycle (bold highlighting inserted).

Phase of disaster cycle: Multiple
"Resilience describes an active process of self-righting, learned resourcefulness and growth—the abilityto function psychologically at a level far greater than expected given the individual's capabilities and previous experiences." Paton, Smith and Violanti, 2000
"Qualities of people, communities, agencies, infrastructure that reduce vulnerability. Not just the absence of vulnerability rather the capacity to 1) prevent, mitigate losses and then if damage occurs 2) to maintain normal living conditions and to 3) manage recovery from the impact." Buckle et al., 2000
"The concept [of resilience] has been used to characterize a system's ability to bounce back to a reference state after a disturbance and the capacity of a system to maintain certain structures and functions despite disturbance. […] resilience of the system is often evaluated in terms of the amount of change a given system can undergo (e.g., how much disturbance or stress it can handle) and still remain within the set of natural or desirable states (*i.e.*, remain within the same 'configuration' of states, rather than maintain a single state)." Turner et al., 2003
"The capacity of a system, community or society potentially exposed to hazards to adapt by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures." UN/ISDR, 2004
"Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary. Resilience in social systems has the added capacity of humans to anticipate and plan for the future." Resilience Alliance, 2005
"The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organising itself to increase this capacityfor learning from past disasters for better future protection and to improve risk reduction measures." UNISDR, 2005
"The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions." UNISDR 2009, p. 24
"The ability of assets, networks and systems to anticipate, absorb, adapt to and/or rapidly recover from a disruptive event." Cabinet Office, 2011 p. 14
"The ability of countries, communities and house-holds to manage change, by maintaining or transforming living standards in the face of shocks or stresses—such as earthquakes, drought or violent conflict—without compromising their long-term prospects." DFID, 2011 p. 6
"The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions." IPCC, 2012 p. 563
"Resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events." The National Academies, 2012 p. 1

some important characteristics. Neither of them is absolute. Rather, a referent (human being/s/, infrastructure, economy, etc.) is vulnerable to a certain hazard (in case of disasters) or other type of impacts. Likewise, resilience can only be visualized if the trigger is taken into context. Thus a system is not resilient per se, but resilient to something [29]. Both vulnerability and resilience became "activated" once the referent is exposed to the particular hazard (trigger or impact). This duality of vulnerability, namely to be composed of a kind of hazard (or impact) independent predisposition which is termed "susceptibility" (for example, [30], see also [31] [32] which through exposure manifests itself as hazard specific vulnerability may be extended also for resilience. It is argued that resilience should, at least predominantly, and certainly in context with disasters, characterize reactive behavior (bouncing back to resume the pre-hazard state again, or bouncing forward into a different, potentially "better", but at least "desirable" state).

Thus it is proposed, in context of disaster and disaster risk management, to identify resilience as the *process* of bouncing back, jumping forward or in certain cases even to jump aside. Resilience is visualized as the first phase of a (presumably swift) recovery just after the hazard event subsided. (See **Figure 1**). During the process of resilience, the referent(s) display resilient behavior. The success (or failure) of resilience is partially dependent upon the underlying *abilities* of the referent(s) which may be activated and relied on during the *process* of resilience. It is useful to define abilities in a very general context of a dynamic recovery potential, independent of whatever type of extreme event(s) might trigger resilience as a *process* to take place. By conceptualizing these resilience *abilities* to be de facto independent of the type and magnitude of potential hazards enables their assessment well in advance of any event, which may trigger a resilience *process*. The quantitative measure of resilience ability and that of resilience processes are scientific challenges on their own. This paper focuses on the theoretical/conceptual distinction between the two and hence prepares the ground for further advances towards respective quantifications.

By splitting, as suggested here, the hitherto ill-defined amorphous term "resilience" into two components:

1) A hazard independent resilience ability; and

2) A hazard dependent resilience process

The use of different names to distinguish them would be warranted. Otherwise the aim of this paper to clarify aspects of resilience and to contribute to its operationalization in disaster risk management would be corrupted. It is suggested that that the resilience *process* retains the term "resilience" or "resiliency" [5], whereas the resilience *abilities* may be abbreviated by the name resiliabilities.

Examples of resiliabilities:

- Mobility (the availability of vehicles and the skill to drive them),
- The availability of easily mobilized monetary assets,
- Availability of actualized documentation of infrastructure, land use and land tenure,

- Well-organized and competent municipal administration, etc.
- Insurance coverage providing protection against a gamut of potential hazards

These examples and similar abilities can be assessed well in advance of the occurrence of whatever calamities the referent(s) may face. No doubt that several other features and abilities that lower susceptibility of socioecological systems would simultaneously also enhance resiliability. Given the relatively short time span of the occurrence of a disaster triggering hazard event and the subsequent resilience process resiliability might be considered constant during this sequence.

However, as part of social development or specific disaster preparedness measures resiliability might be enhanced. However, through social decline or neglect resiliability can decrease with time as well. Vulnerability and resilience are treated as orthogonal, meaning that they compose two axes of a graph.

As far as resilience (the process) is concerned it is worth to distinguish different types of it, thus contributing to the more refined characterization of precautionary or recovery aspects of resilience. As Figure 1 and Figure 3 display, the resilience process may be triggered upon the realization of a disaster risk, thus prior to the occurrence of a hazard impact. This phenomenon to be distinguished as presilience could be visualized for an individual as avoiding to be hit

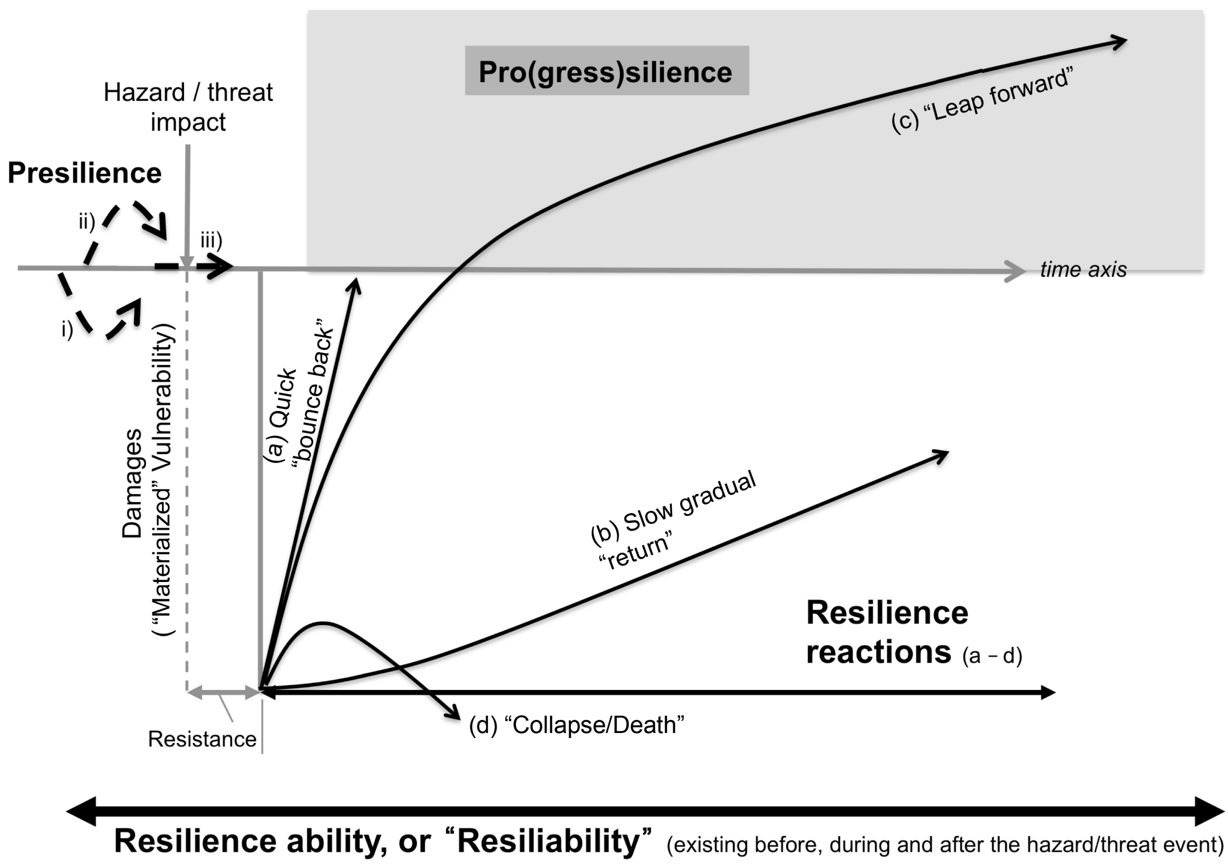

Figure 3. Visualization of the concept of resilience, the pre-emptive form of "presilience", the resilience reaction phase and its possible subtypes, prosilience and the general ability for resilience (resiliability).

by a car by jumping aside before the collision happened. Ordering and implementing rapid evacuation by following early warning could also be seen as presilience for an entire community. By removing the vulnerable referents from harm's way, through the reduced exposure of vulnerability, losses could be reduced significantly. Thus capacities can be saved for the post trauma resilience process.

Disasters, even devastating ones offer a certain "window of opportunity". Consequently, during the resilience/recovery period the social and political readiness to capitalize on the hazard-triggered social awareness and improve the potential preparedness of the impacted referent (to face the next occurrence of a hazard better equipped) can be possible. This could imply that the process does not finish with the completion of the resilience phase (reaching the pre-disaster "performance" level, but continues with progress in socioeconomic development and preparedness. Thus the continuing improvement associated with the progressive part of resilience can be identified as prosilience. It can be expected that the process of prosilience coincides with an increase of resiliability. Thus resilience processes and abilities are sequentially intertwined within the so-called disaster cycle. **Figure 1** and **Figure 3** depict the different resilience phases, including the undesirable option of resilience failure leading to permanent destruction, collapse or/and abandonment the hazard impacted area, or/and the death (or complete destruction) of the referent(s).

6. Discussion of the Proposed Phases of Resilience

6.1. Presilience

While theoretically a reaction before disaster strikes is plausible, or even encouraged by programs such as disaster risk prevention, can it be observed in real cases? Pedestrians jumping back before overrun by a car, truck, train or else are certainly evocative examples. But what about other fields—can whole communities perform "leaps" like this? Would rapid evacuation in face of an approaching flood wave or other hazards classify as presilience? Communities that sharply and significantly change course so as to avoid disaster impacts are harder to capture in such quick and uniform processes. Taking down buildings before they can collapse as a joint community effort could be such a theoretical example. When a virus compromises a computer system, a system shutdown is a step back in functionality that may help to save the whole system from full destruction.

More importantly and as slower, though more steady process, presilience is probably a better name for what many have in mind when using the term resilience to describe an overall strategic mindset and actions for summarizing all types of preparations to avoid, prepare for, mitigate, reduce etc. disasters. A presilient community may be seen as one that embraces and implements the precautionary principle. The importance of preparedness and action as well as planning before disaster strikes or risks evolve to stressors that impair life or functionality of systems, is in line with such a principle. It is however suggested to distinguish between inherent preparation (which de facto helps enhancing resiliability) and presilience which is conceptualized here as a pre-ignited response process. As shown in **Figure 3**, presilience is defined as a very specific phase just before the hazard impact, when the resiliability is activated by the perception of the immediate realization of risk. Such pre-event resilience relies on those parts of resiliability in triggering the process that can help to avoid hazard and hence, disaster impact by swift actions. Evacuation, or moving high value assets to higher level in case of floods can be classified as this type of actions.

The order in the example curves i), ii), and iii) does not imply a logical or process order, but is to display three general possible ways how presilience can manifest itself as a process.

i) the "bounce" takes place before hazard or threat impact the referent under investigation. In i) the bounce itself first occurs in the negative system state direction, to the damage side, downwards. Later on, the system stabilizes and manages to redirect towards an upward movement. While the system manages to re-stabilize, it has overall experienced a strain on its resources and process path, displayed by this, initially downward curve.

An example might be a ship avoiding hitting another ship by using additional energy and efforts, straining structure and personnel thus having less energy and awareness for dealing with other processes for a certain time until the collision is avoided. In case of avoiding to be hit by a car, the presilient reaction of a person could be to suddenly interrupt crossing the street, by recognizing almost too late the rapidly approaching car. While quickly jumping back, the collision might be avoided, but breaking an ankle in the process. Communities, which evacuate in face of imminent hazard events may save themselves from the worst, but can still suffer physically and mentally and have to absorb losses on property left behind. In an overall assessment presilient behavior will be regarded as a success, but occasionally with a negative touch, a broken ankle, stress, or resource and property losses.

In curve ii), however, the same process takes place, but the system, temporarily experienced an upward bounce before it bounces back. An example might be a child running onto the driveway, not noticing a car approaching. Presilience can either occur from the child's own skills, by suddenly jumping back and avoiding collision. The child has used physical energy and was briefly also psychologically stressed, but in overall balance, it has also experienced a rapid learning process and a positive test of physical skills without any collateral damage, The overall experience is a positive, uplifting one, leading to progress and evolution. In an example with external help involved, an adult may save the child from being overrun by the car, by dragging it to the side just in time. After such an incident the whole event may have positive reflections. It may be memorized by both the adult and the child as a successful intervention, where existing resources and skills have been used above normal levels (increased alertness, quick reaction etc.) avoiding the hazard without any lasting negative or positive impact.

Curve iii) resembles the simple bouncing movement that helps avoiding the hazard and its impact without utilizing extra resources and skills. Opening the dyke to cap the flood peak by storing water in emergency flood storage space, thus allowing more time for an orderly evacuation of a menaced community downstream could be an example of presilience at societal scale.

All displayed arrows in Figure 3 are idealized models with significant simplifications. For example, in reality no such movement would be a straight line or a smooth curve. The movement would include many irregular ups and downs.

6.2. Resilience Immediately after Hazard Impact (Reactive Resilience)

This is the phase typically identified with resilience by most who work with this term in the disaster management context. However, there is considerable confusion over distinguishing resilience phase and resiliabilities that can be activated before, during or after a hazard impact. The present conceptualization of resilience as a process adheres to the fundamentally "bounce back" notion of resilience. Therefore it is important to differentiate and explain this phase in more detail.

In Figure 3 the first type of reaction in mind is either a quick bounce back (a) or a slow gradual return (b). Both are common in natural hazard contexts as well as in man-made or technical contexts. There is no straight-forward relationship between sudden hazards and sudden reaction, to pick out one combination example; a sudden earthquake can lead to slow gradual recovery over years, for example. Resilience may be triggered not immediately after the hazard impact (destroyed infrastructure, fear of further tremors etc.) However, there are even more forms of resilience (or the lack of it) reactions, such as collapse and/or death (trajectory d in Figure 3). The noteworthy aspect about this, possibly overlooked so far, is the variety in reaction types that can be related to the hazard, the context but also to the set of abilities of the system or person(s) affected. For example, it might not have been analyzed yet, whether and how the structure and relative strength of resiliability components influence the course and results of the resilience process.

Active or passive resilience? Another aspect to be considered is whether resilience is fundamentally an active or passive process. Going back once more to the literal (Latin) meaning of the word resilience, it does not reveal clearly whether it is an active or passive act. It also does not denominate whether resilience happens before or after an impact. Resilience is often translated into "bouncing", thus a reactive process after an impact. It seems that the conceptual thoughts in context of disasters often consider resilience to be a reaction of a system to a specific impact. Meaning, the impact (almost automatically) pushes a referent into a reactive behavior. Even when the follow-up reaction of bouncing is based on internal capabilities and activated resiliabilities of the referent, it is still motivated and driven by the external stressor. This automatically triggered resilience may be valid (up to a certain physical limit) for materials like rubber or steel. However, humans (both as individuals and social groups) may decide how and when start the resilience process based on the assessment of losses, options and resiliabilities to act. Thus the magnitude of the hazard and its consequences, as pointed out by Beer [33], can have a considerable influence on how resilience unfolds.

So while resilience can conceptually be seen as a process in a specific time phase when the stressor is about to hit or, already has hit, the resiliability in context to a real disaster event has to be created before the event, but will also develop during and after the event. It could help to resolve the debates as to whether resilience is "just" bouncing back or bouncing forward, whether it has preparedness character (resiliabilities) or is just the reactive process. These dilemmas were also often the subject of disputes between social and technically oriented scientists [8]. It is strongly believed that the proposed dual concept of resiliabilities and resilience as a process contributes substantially to clarify these issues. However, by observing the nature of the ongoing resilience discourse it is expected that this proposal would also trigger discussions. Such discussion will be in line with current approaches seeking to conceptually deepen the understanding of resilience by introducing more nuanced conceptual structure [33], [34]. But it will also help approaches trying to measure or apply resilience by clarifying the oftentimes overlapping usages of similar terms such as resilience and degree of loss [35].

6.3. Prosilience

Prosilience or progress-related resilience, is the part conceptually separated from and following the immediate reaction phase of resilience so as to denote its forward looking characteristics. A prosilience trajectory is shown as curve c in **Figure 3**. "Prosilient" interpretation of resilience is often demanded by those abhorring a mere reactive interpretation of resilience. It seems plausible, that a system that has been impacted, be it a human individual being affected physically or psychologically, or be it a stressed beam in a building or any other example, it is likely that quite a number of such affected persons or objects need time to recover their full functionality. This can either take seconds or years, but there is a need to separate a "return to normal" functionality from any progress or evolution the referent can experience (usually afterwards, at least in measurable form). As soon as this progress starts, it is suggested to differentiate between this phase and the preceding resilience reaction phase. Hence it is termed as the prosilience phase. This prosilience phase can then evolve into adaptation or sustainability, or normality, whatever term may be used for this new state of the system. While this distinction works conceptually, in reality it is a great challenge to determine when recovery resilience reaction and then prosilience processes may finally transit the referent system into a new state virtually independent of the magnitude of the preceding hazard impact.

As an example, it is difficult to figure out when a city has recovered from a disaster. Even when population numbers are available on a monthly basis, there are ups and downs, and after several years it is hard to estimate, which level the city would have achieved in terms of population without the hazard impact.

7. Demand for a Scientific, Not Normative Conceptualization of Resilience

As the juxtaposition of the presented conceptualization of resilience, some authors consider resilience to be more than a scientific model; rather a concept or paradigm to be used to enable citizens to enact change, push governance, utilize power or guide transformation [20] [36]. In this context resilience is on its way towards an ideological concept, which can only capture half of the truth. Then there exist also problems that are willingly glossed over. Why should normatively, a bounce back or leap forward always be positive for the outside observer or people affected? As an example, ubiquitous and affordable, controllable robotics could be a major leap forward for human evolution and well-being. However, a sizeable portion of the present population fears losing identity when experiencing this (most likely unavoidable) leap. Whether fast technological development without adequate built-in redundancy and safety protocols would not increase susceptibility and vulnerability is a more than justified question. Would the increase of development-associated vulnerability undermine both resiliability and ultimately resilience?

What is the benefit of vulnerability over resilience? It directly and openly addresses the weaknesses. While there have been many arguments against this "negative narrative"; should not there be a research line dealing with disasters that is ideologically free of mindcuffs?

In disaster risk research the pendulum of fashionable terms has a long tradition in swinging back and forth. It might be time to take courage and question the existing normative ideology and paradigms just as much as it has been expressed for decades by those who have overturned previous paradigms. As an early example, White [37] had shown that hazards and disasters such as floods have a significant human component. However, it took decades to overturn the then prevailing research (and especially, policy) stream that put the focus solely on natural hazards and processes unfolding from it. The International Decade for Natural Disaster Reduction (1990-1999, in [38]) is often used as a reference datum, almost 50 years past Gilbert White's first publication. It is therefore no surprise that the "achievements" of the "new paradigm" focusing on the human side (disasters and risks are considered as social constructs, see also [39], the vulnerability side [40], and more recently the resilience side are being developed amid vivid debates. This trend led to the multitude of resilience definitions seen in **Tables 1-3**).

This paper suggests more scientific rigor using resilience by demanding clarifying qualifiers to distinguish, whether researchers mean resilience in the way of all-encompassing characteristics, or, if resilience is considered as an observable phase of recovery of a disaster hit referent. Suggestions of terms describing the time phase and the characteristics of a resilient reaction were made in this paper. However, it can well be that the suggested terminology would need further refinement. It is however a contribution towards a more open debate over resilience. The concept and terminology suggested in this paper may serve as a bridge between those who reject resilience as primarily a bouncing-back process and rather talk about a forward-looking, transformative, all-encompassing feature they summarize also under the same term "resilience", and those who would rather see resilience as *ability and process*, well defined and in the future preferably quantifiable towards practical applications, at least within the disaster management context.

8. Potential Critical Opinions on the Suggested Differentiation of Resilience

Since this is a conceptual paper and contains new ideas at an initial stage, it is difficult to foresee the range of implications and critique it may provoke. One critique might be on the limitation of transfer of the dual interpretation of resilience as ability and process to social or community resilience approaches or to contexts, wherein society is targeted. Some authors have criticized already the 'bounce back' understanding of resilience in being not appropriate to use in bringing back societies to the previous state before disaster struck [18]. The Sendai Framework for DRR [41] contains a similar warning in its priority 4 to "build back better"; therefore, it is not just social systems, but also buildings and other structural as well as nonstructural areas where a "bounce back" might not be the best of possible solutions and therefore, resilience must be more than that.

The idea presented in this paper is outlined with the help of simplified graphs. Critics may claim that no real event follows such "idealized" recovery and time lines. Resilience as bounce back is too limited for many participants of the resilience discourse. In **Figure 3** this is addressed, however, since there is not just a bounce back, but also a prosilience phase included. Yet, it is admittedly still an idealized conceptual model. While all models are simplifications, some are still useful. However, here the main focus is on the real meaning of resilience. Resilience includes the notion of "springing back". Therefore, this is still its core meaning. Resilience is revealed when it manifests itself in actions, and can be observed as a process. While in the resilience discourse most actors rather mean the normative idea of what resilience should all cover. This "ability" side of resilience is encapsulated here in the term "resiliability".

A bounce back to the preceding state might not be always a desired outcome. But in **Figure 3**, this is just one of many possible post disaster outcomes. It must also be questioned whether the critique on the mal-application of a bounce back notion of social systems is fully correct. It first might be the case that irrespective of normative hopes, the revealed resilience after disasters might in fact lead back to the pre-disaster state. It might also be wrong to propose that this bouncing back always has to be negative as much as it is wrong suggesting this is always a positive outcome. The (social) resilience target of wealthy home-owners might be just to build back (or bounce back). Restoring the status quo could also be the target even for poor people or other social groups. There is also a danger of stereotyping poor people as the sole victims of disasters. Consequently, the conceptual models presented here avoid any such normative implications and provide for all possible outcomes of the resilience process. The bounce forward notions, the transformation etc. are either future phases of recovery or development once the immediate impacts of hazards or stressors have been compensated for. In terms of the resilience ability these phases can be interpreted as the realization of normative wishes and ideals (like achieving a sustainable, or climate proof city). They may coincide with the development and innovative combinations of resiliabilities of the referent.

9. Conclusions

No doubt that irrespective of critical warning words [5] [18], the metamorphosis of the original Latin expression for "bouncing back" towards an all-encompassing umbrella term for many positive features and processes counteracting system collapse and disturbances is still going strong. Intergovernmentally acknowledged and internationally used, the term "resilience" is likely to gain further momentum. Regretfully, the more it is used, the less it might be understood. Thus ringing the bells for the requiem of an interdisciplinary buzzword could be as of 2018 a premature gesture. As of a quantitative, practically useful and crisply defined resilience is concerned mourning cannot be ruled out [42] unless much intellectual effort and consensus thinking is invested towards its resurrection. With its focus on the recovery process resilience studies could provide the much-needed contributions and extensions to the trigger and disturbance (collapse) oriented hazard, vulnerability and risk studies. Towards this renaissance this paper proposes to explore the dual nature of resilience; the hazard-independent resiliability and resilience as a potentially multiple phased process in the context of the hazard affected system (referent). By considering a hazard-independent core part (resiliability), general features of resilience could be assessed for different systems. It is argued that the use of the term resilience should be confined to "bouncing and jumping" processes within the broader context of recovery phases. Resilience of course may occur simultaneously at different time scales (fast and long-term recoveries etc.) and in different fields (dimensions by the terminology of Bruneau *et al.* [6]). This paper introduces the pre-emptive form of resilience, avoiding an impact by "bouncing forward" before it hits, as "presilience". The suggested process prosilience extends the recovery phase towards development and evolution of the (once impacted) referent. During and after the prosilience phase resiliabilities may be enhanced. Thus the experience gained with the preceding hazard event may be translated into better preparedness for the future.

For meaningful quantification resilience metrics should rather focus one by one on these different resilience trajectories than amalgamating them in an amorphous (and ill-defined) all-encompassing resilience measure. Hence it is likely that several resiliencies have to be acknowledged and need to be monitored parallel to each other. These distinct resiliencies may be set into motion by the exposure of the referent to certain sort and level of hazard impacts. By looking at resilience through this lens then the need for focused research is obvious. It seems however, that serious resilience research should urgently emancipate itself from the ongoing "buzzword generation".

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References

[1] Béné, C., Godfrey Wood, R., Newsham, A. and Davies, M. (2012) Resilience: New Utopia or New Tyranny? Reflection about the Potentials and Limits of the Concept of Resilience in Relation to Vulnerability Reduction Programmes. IDS Working Paper No. 405, CSP Working Paper No. 006, 61.

[2] Chandler, D. (2014) Beyond Neoliberalism: Resilience, the New Art of Governing Complexity. *Resilience*, **2**, 47-63. https://doi.org/10.1080/21693293.2013.878544

[3] Wink, R. (2016) Multidisziplinäre Perspektiven der Resilienzforschung. Studien zur Resilienzforschung. Springer, Wiesbaden. 215-232. https://doi.org/10.1007/978-3-658-09623-6

[4] Manyena, S.B., O'Brien, G., O'Keefe, P. and Rose, J. (2011) Disaster Resilience: A bounce Back or Bounce forward Ability. *Local Environment*, **5**, 417-424.

[5] Alexander, D. (2013) Resilience and Disaster Risk Reduction: An Etymological Journey. *Natural Hazards and Earth System Sciences*, **13**, 2707-2716. https://doi.org/10.5194/nhess-13-2707-2013

[6] Bruneau, M., Chang, S.E., Eguchi, R.T., Lee, G.C., O'Rourke, T.D., Reinhorn, A.M., *et al*. (2003) A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. *Earthquake Spectra*, **19**, 733-752. https://doi.org/10.1193/1.1623497

[7] Manyena, S.B. (2006) The Concept of Resilience Revisited. *Disasters*, **30**, 434-450. https://doi.org/10.1111/j.0361-3666.2006.00331.x

[8] Fekete, A., Hufschmidt, G. and Kruse, S. (2014) Benefits and Challenges of Resilience and Vulnerability for Disaster Risk Management. *International Journal of Disaster Risk Science*, **5**, 3-20. https://doi.org/10.1007/s13753-014-0008-3

[9] Simonovic, S.P. and Peck, A. (2013) Dynamic Resilience to Climate Change Caused Natural Disasters in Coastal Megacities Quantification Framework. *British Journal of Environment and Climate Change*, **3**, 378-401. https://doi.org/10.9734/BJECC/2013/2504

[10] Simonovic, S.P. and Arunkumar, R. (2016) Comparison of Static and Dynamic Re-

silience for a Multipurpose Reservoir Operation. *Water Resources Research*, **52**, 8630-8649. https://doi.org/10.1002/2016WR019551

[11] Hashimoto, T., Stedinger, J.R. and Loucks, D.P. (1982) Reliability, Resiliency, and Vulnerability Criteria for Water Resource System Performance Evaluation. *Water Resources Research*, **18**, 14-20. https://doi.org/10.1029/WR018i001p00014

[12] Duckstein, L., Plate, E.J. and Benedini, M. (1987) Water Engineering Reliability and Risk: A System Framework. In: Duckstein, L. and Plate, E.J., Eds., *Engineering Reliability and Risk in Water Resources*, Martinus Nijhoff Publishers, Dordrecht, 1-20. https://doi.org/10.1007/978-94-009-3577-8_1

[13] Holling, C.S. (1973) Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics*, **4**, 1-23. https://doi.org/10.1146/annurev.es.04.110173.000245

[14] Holling, C.S. (1986) Resilience of Ecosystems: Local Surprise and Global Change. In: Clark, W.C. and Munn, R.E., Eds., *Sustainable Development and the Biosphere*, Cambridge University Press, Cambridge, 292-317.

[15] Holling, C.S. (1996) Engineering Resilience versus Ecological Resilience. In: Schulze, P., Ed., *Engineering within Ecological Constraints*, National Academy Press, Washington D.C., 31-44.

[16] Holling, C.S. (2004) From Complex Regions to Complex Worlds. *Ecology and Society*, **9**, 1-10. https://doi.org/10.5751/ES-00612-090111

[17] Homeland Security Studies and Analysis Institute (2010) Risk and Resilience. Exploring the Relationship. Homeland Security Studies and Analysis Institute, Arlington.

[18] Weichselgartner, J. and Kelman, I. (2014) Geographies of Resilience: Challenges and Opportunities of a Descriptive Concept. *Progress in Human Geography*, **39**, 249-267. https://doi.org/10.1177/0309132513518834

[19] Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T. and Rockström, J. (2010) Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society*, **15**, 20. https://doi.org/10.5751/ES-03610-150420

[20] Kuhlicke, C. (2013) Resilience: A Capacity and a Myth. Findings from an In-Depth Case Study in Disaster Management Research. *Natural Hazards*, **67**, 61-76. https://doi.org/10.1007/s11069-010-9646-y

[21] MacAskill, K. and Guthrie, P. (2014) Multiple Interpretations of Resilience in Disaster Risk Management. *Procedia Economics and Finance*, **18**, 667-674. https://doi.org/10.1016/S2212-5671(14)00989-7

[22] Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., *et al.* (2003) A Framework for Vulnerability Analysis in Sustainability Science. *Proceedings of the National Academy of Sciences of the United States of America*, **100**, 8074-8079. https://doi.org/10.1073/pnas.1231335100

[23] Moberg, F. and Simonsen, S.H. (2012) What Is Resilience? An Introduction to Social-Ecological Research. Stockholm Resilience Centre, Stockholm, 19.

[24] Hollnagel, E. (2017) Resilience Engineering and the Future of Safety Management. In: Moller, N., *et al.*, Eds., *Handbook of Safety Principles*, John Wiley & Sons, Inc., Hoboken, NJ. https://doi.org/10.1002/9781119443070.ch3

[25] Kelman, I., Gaillard, J.C. and Mercer, J. (2015) Climate Change's Role in Disaster Risk Reduction's Future: Beyond Vulnerability and Resilience. *International Journal of Disaster Risk Science*, **6**, 21-27. https://doi.org/10.1007/s13753-015-0038-5

[26] Coetzee, C. and van Niekerk, D. (2012) Tracking the Evolution of the Disaster

Management Cycle: A General System Theory Approach. *Jàmbá: Journal of Disaster Risk Studies*, **4**, 9. https://doi.org/10.4102/jamba.v4i1.54

[27] Gunderson, L.H. and Holling, C.S. (2002) Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, Washington.

[28] Thywissen, K. (2006) Components of Risk: A Comparative Glossary. SOURCE No. 2/2006. UNU-EHS, Bonn, 52.

[29] Carpenter, S., Walker, B., Anderies, J.M. and Abel, N. (2001) From Metaphor to Measurement: Resilience of What to What? *Ecosystems*, **4**, 765-781. https://doi.org/10.1007/s10021-001-0045-9

[30] Davidson, R.A. and Shah, H.C. An Urban Earthquake Disaster Risk Index, in Stanford Digital Repository. John A. Blume Earthquake Engineering Center Technical Report 121. https://stacks.stanford.edu/file/druid:zy159jm6182/TR121_Davidson.pdf

[31] Fekete, A. (2010) Assessment of Social Vulnerability to River-Floods in Germany, in Graduate Series 2010. United Nations University—Institute for Environment and Human Security (UNU-EHS), Bonn.

[32] Bogardi, J.J., Damm, M. and Fekete, A. (2011) Multidimensional Indices to Capture Vulnerability to River Floods. In: Eulisse, E., Ed., *Challenges in Water Resources Management Vulnerability, Risk and Water Resources Preservation*, Civiltá dell'Acqua International Centre, Università Ca'Foscari Venezia, 49-63.

[33] Beer, T. (2004) Geophysical Risk, Vulnerability, and Sustainability. In: Sparks, R.S.J. and Hawkesworth, C.J., Eds., *The State of the Planet: Frontiers and Challenges in Geophysics*, International Union of Geodesy and Geophysics, American Geophysical Union, (Geophysical Monograph; 150, IUGG; 19) Washington D.C., 375-385.

[34] Amir, S. and Kant, V. (2018) Sociotechnical Resilience: A Preliminary Concept. *Risk Analysis*, **38**, 8-16. https://doi.org/10.1111/risa.12816

[35] Zhang, N. and Huang, H. (2018) Resilience Analysis of Countries under Disasters Based on Multisource Data. *Risk Analysis*, **38**, 31-42. https://doi.org/10.1111/risa.12807

[36] Pelling, M. (2011) Adaptation to Climate Change: From Resilience to Transformation. Routledge, Oxon.

[37] White, G.F. (1945) Human Adjustment to Floods. A Geographical Approach to the Flood Problem in the United States. In: Chicago, T.U.O., Ed., *Research Paper No.* 29, The University of Chicago, Chicago.

[38] UN (1987) International Decade for Natural Disaster Reduction.

[39] Luhmann, N. (1993) Risk: A Sociological Theory. de Gruyter, Berlin.

[40] Bogardi, J.J. and Birkmann, J. (2004) Vulnerability Assessment: The First Step towards Sustainable Risk Reduction. In: *Disasters and Society—From Hazard Assessment to Risk Reduction*, Universität Karlsruhe, Logos, Berlin.

[41] United Nations (2015) Sendai Framework for Disaster Risk Reduction 2015-2030. United Nations Office for Disaster Risk Reduction, Geneva.

[42] Sword-Daniels, V. (2017) Too Complex to Measure? Exploring the Dynamic Processes of Resilience and Recovery. ITAD Limited.