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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Towards Measuring Resilience of Flood Prone Communities: A Conceptual Framework" *by* Victor O. Oladokun and Burrell E. Montz

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REVIEWER's COMMENT –Section 1a This paper adds to expanding literature on disaster resilience measurement. The primary purpose of the study is to develop a mathematical model based on the U.S. National Academies definition of resilience ("the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events") and then implement the model for three flood-prone communities using a fuzzy logic equivalent. AUTHORS' RESPONSE to REVIEWER COMMENT –Section 1a Comments reflect the broad scope of the paper

REVIEWER's COMMENT –Section 1b The background on the development of op-

erational resilience measurement models is good, although it does rely primarily on relatively few papers (e.g. Cai et al. 2018; Cutter 2018; Keating et al. 2017; Zou et al. 2018), and perhaps misses other community resilience measurement efforts such as Zurich's Flood Resilience program. AUTHORS' RESPONSE to REVIEWER COMMENT –Section 1b While efforts will be made to include other relevant papers, the authors wish to state that the Zurich flood resilience program was considered through one of the papers. The Zurich resilience measurement work was the focus of Keating et al (2017) that we cited. Quoting from paragraph 2 on 2nd page of Keating et al (2017), "The primary purpose of this paper is to present the Zurich Alliance community flood resilience measurement framework and associated tool, developed by an alliance of NGOs, academic institutions, and the private sector."

REVIEWER's COMMENT –Section 2a I am also concerned that the definitional discourse does not adequately describe the complexities and variability in the meaning of resilience as it is applied to a particular system, event, or more broadly to capture community abilities as the NRC definition is designed to do? AUTHORS' RESPONSE to REVIEWER COMMENT –Section 2a This definitional discourse recognizes the community as a complex coupled system. Some of the variability and complexity were highlighted in section 1. For instance, we noted that the concept of resilience involves the interactions of several entities each defined by some social, economic, natural, technical and environmental dimensions, each of which we described as characterized by dynamic and complex spatiotemporal interactions.

REVIEWER's COMMENT –Section 2b I would encourage the authors to reduce the definitional discussion and simply select and then justify the definition they prefer to use (e.g. NRC 2012) as the basis for their conceptual model. AUTHORS' RESPONSE to REVIEWER COMMENT –Section 2a This suggestion is noted and will be explored in the revision

REVIEWER's COMMENT –Section 2b In the formulation of the conceptual mode (Figure l,) the authors assume that resilience leads to recovery (the outcome of interest).

How does the conceptual model line up with their preferred definition? While an attempt was made on p. 5-6 to do this, most of the discussion is focused on recovery or the recovery spectrum. So, how can the operationalization of a definition that includes recovery also be used to measure an outcome, also labeled recovery? AUTHORS' RESPONSE to REVIEWER COMMENT –Section 2b We appreciate the need to improve the clarity of Figure1, firstly by using a two-way arrow arc to depict the interaction between resilience and recovery and secondly by enhancing the explanation of the figure with respect to the proposed model. We say our model is our interpretation of the definition as well as our understanding of the interactions within resilience. Our schematic model for instance recognizes that resilience enhances recovery or that recovery is an outcome of resilience whereby when a community, as a coupled system, becomes more resilient, its capacity to experience post disaster recovery increases. In other words, recovery, in terms of the time taken to attain post disaster recovery and the degree of recovery attained, are influenced by the resilience. This understanding is supported by the DROP resilience model as illustrated in Cutter, Barnes, Berry, & Burton (2008).

DROP model reproduced from Cutter et al 2008 âĂČ Thus, our model implicitly suggests that recovery (i.e., recovery time and quality) can be a substitute for resilience. This is reasonable because post disaster recovery is driven by inherent resilience factors some of which we further explained in table 3 of this paper.

REVIEWER's COMMENT –Section 3 The authors need to clearly distinguish resilience (an outcome in and of itself) from recovery or at a minimum more clearly articulate they are describing resilience-type capacities within communities that influence flood recovery. It seems to me that the conceptual model is oriented to flood recovery (p. 7) rather than resilience per se. Later on in the paper, they use the resilience index as the output (Table 6), but this is not found in the conceptual model as described in Figure 1). AUTHORS' RESPONSE to REVIEWER COMMENT –Section 3 It should be noted that this reviewer's comment underpins our argument about how the absence

of consensus on definition leads to divergent interpretations of the interactions among the components of the resilience system. According to Cutter, Barnes, Berry, & Burton (2008), multiple definitions of resilience exist within the literature, with no broadly accepted single definition. Our schematic model for instance recognizes that resilience enhances recovery or that recovery is an outcome of resilience whereby when a community, as a coupled system, becomes more resilient, its capacity to experience post disaster recovery increases: pre-disaster resilience affects recovery, but post-disaster recovery can also affect resilience.

REVIEWER's COMMENT –Section 4 What is unique about the context of flood hazards in the model, or could it equally apply to any natural hazard impact in a community? AUTHORS' RESPONSE to REVIEWER COMMENT –Section 4 The focus of the model is flood hazards. Flood hazards share characteristics with other natural hazards. This focus was also reiterated in the conclusion of the paper

REVIEWER's COMMENT –Section 5 The bulk of the paper describes the mathematics of the model and its implementation, but again I wonder as to whether the model is describing and/or modeling resilience. AUTHORS' RESPONSE to REVIEWER COMMENT –Section 5 We have attempted to model resilience using three types of models: 1) a descriptive model that outlines our abstract interpretation of community resilience as a system; 2) a mathematical model equivalent of 1 illustrated using geometric reasoning; and 3) a fuzzy logic equivalent of 2 for the purpose of computational analysis in the face of limited and subjective data.

REVIEWER's COMMENT –Section 6 What is the source of the resilience input factors? Were the inputs verified to see if the model worked? In the "hypothetical" analysis who determined the inputs (e.g. who did the assessment as to the values of the inputs)? There is no explanation of this in Section 4 Model Application, just a very generic text about the study location. When the "results" appear, they are more like a description of the tool and how it can be used rather than results based on empirical and/or qualitative assessments. Thus, the information presented in the manuscript does not

support the results as presented. In addition, the discussion and conclusion section is not especially robust either and in many ways rehashes the literature review rather than presenting new and innovative findings related to resilience in flood prone communities. This paper could be significantly improved by re-framing it as a methodological contribution where the conceptual model and its mathematical expression is more fully articulated including all the requisite input variables including the sources. Then the fuzzy logic scoring template/tool can be described in more detail. In order to test the model, however, the authors would need to generate at least a small sample of stakeholders to complete the input variable assessments as a measure of the validity of the effort. This is a difficult paper to assess given how much of it seems focused on the modeling (Figures 2-6) and recovery quality, yet in these same figures there's no mention of the other two components (resource availability and resource utilization processes) unless these are both subsumed under resources per Figure 3. As a reader I do not understand the model and its conversion to a type of resilience index (the stated output). Whether this is a function of my lack of familiarity with mathematical modeling as used here or the authors' explanation of it is uncertain. Either way, the manuscript needs a rewrite to make it appeal more directly to the journal's readership. AUTHORS' RESPONSE to REVIEWER COMMENT –Section 6 An extensive literature search was the basis for identifying the input variables/ factors. The whole essence of adopting a soft computing tool, fuzzy logic, is to enable subjective opinions and limited data to be summarized using linguistic variables as input into the inference system. A fuzzy inference system/ model of resilience is a template that allows experts and other stakeholders to translate their perceptions of the problem and map their linguistics rating of these variables into an index based on the fuzzy computational relationships we have defined. This will be emphasized in the revision. Our sample application was based on the outcome of field study, reflective interactions with experts, and stakeholders familiar with study locations. Our sample scoring was therefore based on our interactions with these various stakeholders, which include academics, community leaders, and our understanding of their opinions, as well as the data extracted from various

historical records. We will make efforts to improve on the explanations for the readers.

Reference Cutter, S. L., Barnes, L., Berry, M., & Burton, C. (2008). A place-based model for understanding community resilience to natural disasters. Global environmental change , 18 (4), 598-606. Keating, A., Campbell, K., Szoenyi, M., McQuistan, C., Nash, D., & Burer, M. (2017). Development and testing of a community flood resilience measurement tool. Natural Hazards and Earth System Sciences. 2017;17(1):77 , 17 (1), 77.

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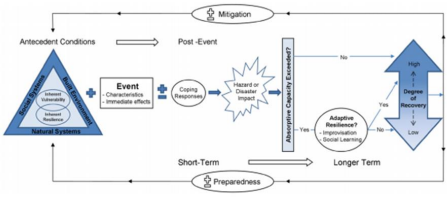
DROP model reproduced from Cutter et al 2008



Schematic representation of the disaster resilience of place (DROP) model.

Fig. 1. DROP Model