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Disastrous Measures: Conceptualizing and Measuring Disaster Risk Reduction¹²

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Abstract:

Despite the large amount of research into disaster risk reduction [DRR], there remain significant difficulties in attempting to measure the impact of these policies. In particular, an urgent priority is the need to produce a theoretical framework for researchers and practitioners to enable the comparative assessment of the success of DRR policies. The measurement of these policies is unsatisfactory, creating a situation where it is almost impossible to assess how well the resources committed to these policies translate to improving DRR in at-risk communities. This article proposes an innovative approach to the measurement of DRR through a minimal procedural operationalization of the concept. The paper illustrates the utility of the framework through presentation of original survey data about individual DRR among residents of California. The results indicate that although most people are aware of measures of individual DRR, they have not advanced beyond that stage to plan and implement those measures themselves. The article marks a critical step towards the better measurement of success of intractable policy initiatives through the introduction of a novel measure of DRR.

Key words: disaster risk reduction, conceptualization, measurement, preparedness, response, recovery
Word Count: 9007

¹ Paper accepted for publication at the *International Journal of Disaster Risk Reduction*. Please cite this article as: Thomas Jamieson. 2016. "Disastrous Measures: Conceptualizing and Measuring Disaster Risk Reduction." *International Journal of Disaster Risk Reduction* 19: 399-412. <http://dx.doi.org/10.1016/j.ijdr.2016.09.010>

² Earlier versions of this paper were presented at the 2015 International Studies Association Annual Convention and at the University of Southern California. The author would especially like to thank Pat James, Anat Niv-Solomon, Jennifer Roglà, Doug Van Belle, Nick Weller, Nicolas de Zamaroczy, participants in the panels, and the three anonymous reviewers for excellent comments on earlier drafts. Any errors that remain are the author's sole responsibility.

1. Introduction

Despite an increased awareness of the benefits of disaster risk reduction [DRR] policies, there remain significant difficulties with the measurement of these policies. In particular, an urgent priority is the need to produce a framework for researchers and practitioners to enable the assessment of the success of DRR initiatives. The objectives of DRR policies are often ill defined and under-specified by policy makers and practitioners alike, so it is sometimes difficult to determine the policy goals. Furthermore, even if the intended outcomes are clearly stated, policymakers face difficulties in the operationalization of the concept in question to measure the effectiveness of DRR initiatives. The measurement of these policies is unsatisfactory, creating a situation where it is almost impossible to assess how well the resources committed to these policies translate to improving DRR in at-risk communities. To address this problem, this article aims to contribute a framework for the better conceptualization and measurement of disaster risk reduction.

In recent years, DRR has become a critical part of developmental goals of states in conjunction working with the United Nations Development Programme [UNDP] to implement the recommendations of the United Nations Hyogo Framework for Action [HFA]. Concurrently, organizations such as the World Bank, various different NGOs [non-governmental organizations], and government departments have prioritized DRR as part of their development initiatives. However, it has been difficult to gauge progress through existing measures used to assess the effects of these policies.

This paper seeks to address this gap through the introduction of a framework for the measurement of efforts at disaster risk reduction through different scales of response, across varying units of analysis, across a variety of natural hazards. In particular, this paper introduces this framework as a means to measure the process of disaster risk reduction by proxy, providing

indirect measures of improvements brought about by policies introduced by states and NGOs to mitigate against the hazards faced by at-risk communities. This paper focuses on the adoption of these measures at the individual level, but it can also be adapted for application to different units of analysis up to the country level.

This article proceeds in eight further sections. First, the paper provides a summary of recent developments in disaster risk reduction. Second, the paper reconceptualizes disaster risk reduction through the introduction of a minimalist, procedural definition. Third, the paper addresses some of the critical problems with existing measures of DRR. Fourth, the paper introduces a framework for the measurement of DRR as a three-stage process. Fifth, the paper discusses how the framework applies to real cases, across different units of analysis and different hazards. Sixth, the paper evaluates evaluate individual disaster risk reduction measures in California to demonstrate the utility of the framework for the measurement of disaster risk reduction. The seventh section suggests some implications of the framework for policymakers and practitioners. Finally, the paper ends with a brief conclusion.

2. Disaster Risk Reduction

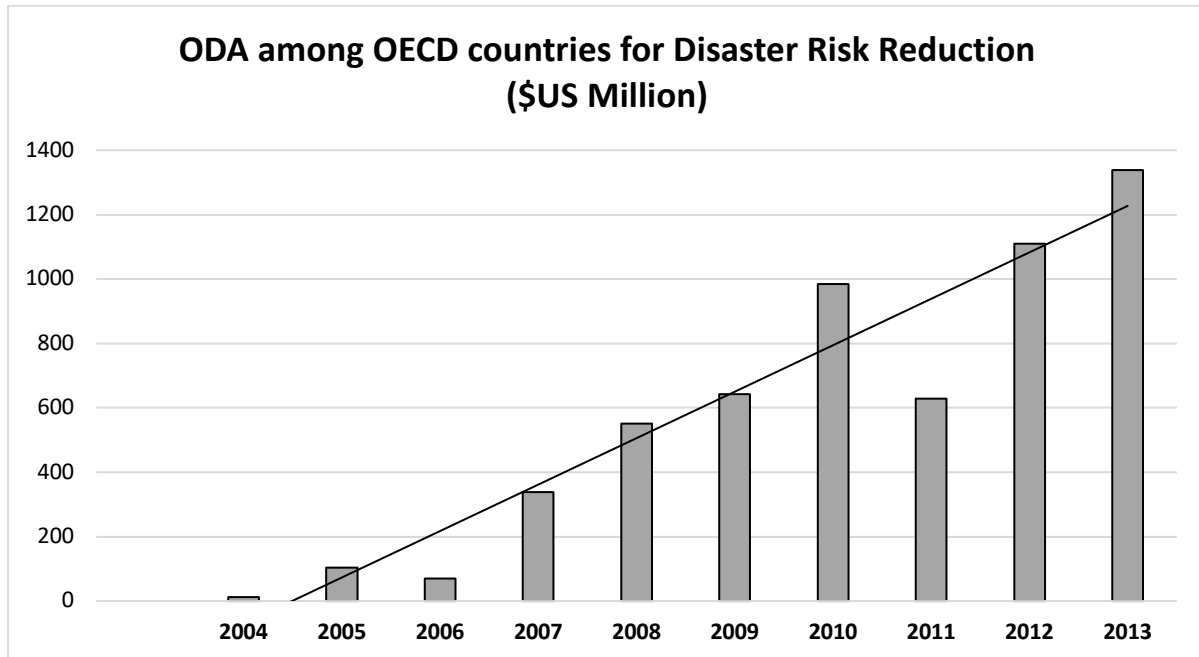
Over the last twenty years, there has been a concerted effort among states, NGOs and transnational networks to better prepare at-risk communities for the risks presented by natural disasters. These efforts typically target vulnerable communities, places with “the characteristics and circumstances of a community, system or asset that make it susceptible to the damage effects of a hazard,” (UNISDR, 2009: 30).

For the most part, DRR has been the domain of developmental organizations, as a by-product of broad developmental initiatives. For instance, Wisner, Gaillard and Kelman (2012: 1) claimed, “It is impossible and fruitless to try to distinguish between human development and DRR” as the two concepts are inextricably linked. Similarly, the UNDP asserted, “The

linkages between development and disaster risk are not difficult to visualize” because “any development activity has the potential to either increase or reduce disaster risk” (2004: i). To illustrate this, they claimed, “While only 11 per cent of the people exposed to natural hazards live in countries classified as low human development, they account for more than 53 per cent of total recorded deaths” (UNDP, 2004: 1). As the culmination of considerable deliberation, representatives at the World Conference on Disaster Reduction drafted the Hyogo Framework for Action, and was subsequently adopted by 168 states. The Framework required states to improve DRR within their own state while developing a coherent global plan for DRR over the following decade (Enia, 2013).

Concurrently, NGOs mobilized to lead efforts assisting developing countries with DRR using foreign aid from both state and non-state actors. NGOs such as the UNISDR under the authority of the UNDP, the United States Agency for International Development [USAID], and the World Bank led initiatives, while states have dedicated a significant amount of their foreign aid towards DRR efforts. As an illustrative example of the type of investment into DRR alone, Figure 1 shows the levels of foreign aid dedicated to disaster prevention and preparedness among Organization for Economic Co-operation and Development [OECD] states from 2004-2013. Although the figures might appear small compared to all official development aid [ODA], they indicate a significant increase of aid donated by countries in the OECD for the implementation of DRR (OECD, 2014). This spending also coincides with a decline in overall ODA in real terms (Tran, 2013); indicating a significant increase in the percentage increase of DRR spending as a proportion of ODA. Crucially, these figures could have exponential beneficial effects.

Figure 1. Total Official Development Aid for Disaster Risk Reduction from OECD countries, 2004-2013.



Source: OECD, 2014.

Although there is disagreement about the savings created by DRR, there is general agreement that these efforts do constitute value for money. Healy and Malhotra (2009: 402) calculated that almost fourteen dollars is saved in relief spending for every dollar spent on preparedness; while UNDP Administrator Helen Clark asserted that “for every dollar invested in minimizing risk, about seven dollars will be saved in economic losses from disasters” (2012). However, little remains known about the effectiveness of DRR efforts. Despite general agreement about the importance of such policies, problems with the current measures of DRR mean that these figures remain guesswork. As such, it is difficult to establish whether the foreign aid is having any effect on DRR outcomes.

3. The Conceptualization of Disaster Risk Reduction

Cumbersome working definitions of DRR complicate the assessment of DRR actions. The conceptualization of natural disasters is difficult because they are too broadly defined for analytical use, and that “everyone seems to define it idiosyncratically” (Olson, Prieto, and

Hoberman, 2010: 5). For instance, Quarantelli contended that a disaster is a “logical and definitional matter” and that it is impossible to define the term empirically (1987: 22). Oliver-Smith described disasters as being socially constructed crises; meaning that they are not only the result of natural processes, but that people create the necessary conditions for a disaster to occur, just as they suffer its consequences (1999: 22-30). Others correctly criticize the use of the word “natural” as misleading because people contribute to their effects, and that scholarly focus should be on “understanding and reducing human and social vulnerability” (Briceño 2012).

Perhaps the most authoritative organization in the promotion of DRR, the UNDP defined a disaster as “a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources” (UNISDR, 2009: 9). Meanwhile, Olson, Prieto and Hoberman defined a natural disaster as: “a social crisis characterized by a sense of great uncertainty, significant disorder, or potential collapse in a community caused by a serious disruption in its normal functioning and involving widespread human, material, economic, or environmental losses and impacts that exceed the community’s ability to cope using its own resources” (2011: 62). Collectively, these definitions offer much in describing the full extent of the social crisis created from natural events. However, these definitions are so broad that it is difficult to operationalize the term into a useful analytical concept for measurement and comparison across cases. As such, this paper offers a minimalist definition as an alternative.

If a natural hazard is a future event that has the potential to endanger people, natural disasters are essentially the realization of that threat when the natural hazard eventuates and affects vulnerable communities (UNISDR, 2009: 17). As such, this author defines a natural disaster as *a discrete natural event that kills people and/or causes economic damage*. This

parsimonious definition runs the risk of neglecting details of social crises included in alternative definitions, but this a risk worth taking in the pursuit of a better-operationalized concept.

Conceptually, DRR is even more problematic. Paralleling the maximalist conceptions of natural disasters, people define DRR in ways that further complicate empirical studies across multiple cases. Wisner, Gaillard and Kelman defined DRR as “the process of understanding, analyzing and managing the causes and origins of disasters and the risks that accumulate and lead to disasters” (2012: 1). The UNISDR definition is more detailed, defining DRR as “the concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events” (2009: 10-11). The UNISDR noted differences between ‘disaster reduction’ and ‘disaster risk reduction’, distinguishing DRR as providing “a better recognition of the ongoing nature of disaster risks and the ongoing potential to reduce these risks” (UNISDR, 2009: 11). Again, despite the detail involved in these conceptions of disaster risk reduction, these maximalist definitions make the measurement of progress in DRR challenging for comparative analysis.

Instead, a minimalist procedural definition offers opportunities for future research into the effects of the time, money, and effort of advocates in pursuit of improved DRR. As such, I define disaster risk reduction as *actions intended to reduce the number of people killed and/or the amount of economic damage caused by a natural disaster*. This definition neatly continues from my minimalist definition of natural disasters, allowing for the evaluation of efforts designed to mitigate against the effects of natural disasters according to two criteria: numbers of people killed, and the amount of economic damage caused.

4. The Measurement of Disaster Risk Reduction

A second critical problem with the evaluation of DRR effectiveness is the quality of measures available. There are five important threats to validity in the measurement of DRR that need addressing for any research claiming improvements to be plausible. First, it is complicated making causal arguments about DRR due to the lack of the consideration of alternative explanations and the absence of controls in case studies of DRR initiatives. In the absence of these controls, it is difficult to rule out alternative explanations for any perceived effects. Second, existing measures of DRR in the HFA are on an ordinal scale. However, problems emerge when scholars treat these variables as continuous, which could lead to misleading conclusions.

A third threat to validity is construct validity. The opacity of DRR as a theoretical construct has made measuring DRR difficult and previous research has failed to operationalize the construct into measures consistent with the concept. A fourth threat to validity is that there are incentives for actors to misreport the extent of progress towards DRR initiatives in existing measures such as the country-level reports submitted to the UNISDR as part of the Hyogo Framework for Action, creating the opportunity for social desirability bias. Finally, despite the HFA suggested integrated approaches to DRR between local communities and states, there are severe shortfalls in the measurement of DRR actions across different units of analysis, from the individual to state level.

4.1. Alternative Explanations

There has been a proliferation of useful research into the implementation of DRR in recent years, but a missing element in previous research is the consideration of alternative explanations of success. Instead, research has tended to involve thorough case studies that describe local vulnerability and mitigation efforts in comprehensive detail (Gaillard and Mercer, 2012; Larsen, Calgaro, and Thomalla, 2011; Mercer et al., 2008; Mercer, 2010; Mercer et al.,

2010; Mercer et al., 2014; Tompkins, Lemos, and Boyd, 2008). However, these studies either do not define DRR or operationalize the concept, making it problematic to evaluate the success of DRR measures across cases.

Perhaps reflecting the maximalist definitions adopted by the field, the state of the art in DRR research frequently involves complex flowcharts and diagrams detailing possible causes and effects of variance in disaster risk reduction between communities or integrated descriptions of the roles of different actors. This important work acknowledges the complexity involved in the social crises brought about by natural disasters.

However, the usefulness of these conceptualizations of DRR is limited. Because of the specific local context described in each case study, the same framework is rarely applicable across cases. Measuring the effectiveness of DRR measures across regions or states is therefore difficult. As an illustrative example of a much broader problem, Tompkins, Lemos and Boyd (2008) compared DRR in the Cayman Islands, and northeast Brazil and Ceará, demonstrating the difficulty of comparing cases using existing measures of DRR effectiveness. Tompkins, Lemos and Boyd (2008) identified their two cases as having different vulnerabilities, but they cited four reasons for success in these efforts: flexibility among actors, policy entrepreneurs, an integrative approach, and a long-term commitment to DRR.

However, the authors never defined disaster risk reduction or operationalized the concept. Though ambitious in scope, the failure to define or operationalize the key concepts makes any causal inference extremely difficult. They also fail to specify how their four independent variables affected the outcomes in these cases, and account for alternative explanations about how these regions improved DRR. This is symptomatic of broader problems with similar studies, where research design problems undermine the validity of the results.

4.2. Levels of Measurement

A second issue with existing measures of DRR is the level of measurement most frequently used remains the state, despite most definitions acknowledging the importance of more local governance in DRR. This likely stems from the fact that disaster risk reduction is difficult to operationalize. The Hyogo Framework for Action enabled the systematic evaluation of DRR efforts at the regional, national and local levels across five priority areas (UNISDR, 2005; Enia, 2013). These five areas for action are: 1) ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation; 2) identify, assess and monitor disaster risks and enhance early warning; 3) use knowledge, innovation and education to build a culture of safety and resilience at all levels; 4) reduce the underlying risk factors; and 5) strengthen disaster preparedness for effective response at all levels” (UNISDR, 2005). Within these areas for action, there are a set of core indicators on which states are expected to self-report their performance on each indicator on a scale from one to five (UNISDR, 2008).

Table 1 illustrates the nature of the self-assessment tool for each indicator through the guidance provided to states in their self-reporting of DRR. The self-reported data from states’ performance in adhering to these guidelines in the Hyogo Framework for Action are currently the best available for evaluating the success of any DRR measures. However, several problems with measurement prevent data generated from these reports from being useful.

Table 1. Five-Level Assessment Tool for Use in Grading Achievement of Qualitative Factors in Hyogo Framework for Action Indicators.

Level	Generic Description of Achievement	Example :
		“A Strategy for Data Provision for Disaster Risk Reduction is in Place”
5	Comprehensive achievement has been attained, with the commitment and capacities to sustain efforts at all levels.	“Systematic, properly resourced processes for data collection and dissemination are in place, with evaluation, analysis and improvements being routinely undertaken. Plans and commitments are publicised and the work is well integrated into other programmes.”
4	Substantial achievement has been attained, but with some recognised deficiencies in commitment, financial resources or operational capacities.	“Processes for data collection and dissemination are in place for all hazards and most vulnerability factors, but there are shortcomings in dissemination and analysis that are being addressed.”
3	There is some commitment and capacities to achieving DRR but progress is not substantial.	“There is a systematic commitment to collecting and archiving hazard data, but little awareness of data needs for determining vulnerability factors, and a lack of systematic planning and operational skills”.
2	Achievements have been made but are relatively small or incomplete, and while improvements are planned, the commitment and capacities are limited.	“Some data collection and analysis has been done in the past, but in an ad hoc way. There are plans to improve data activities, but resources and capacities are very limited.”
1	Achievements are minor and there are few signs of planning or forward action to improve the situation.	“There is little awareness of the need to systematically collect and analyse data related to disaster events and climatic risks.”

Source: UNISDR, 2008.

First, the scales used for the measurement of DRR in the HFA are ordinal measures. However, scholars and policymakers treat the variables as interval or ratio measures. The guidelines (UNISDR, 2008: 6) claimed, “Indicators need to be quantifiable to have value in a monitoring or assessment oriented process.” As a result, the report (UNISDR, 2008: 6-7) suggests that the evaluator “qualitatively assess the indicator using a graduated 5-point scale from ‘no/minor progress’ through to ‘full/substantial achievement.’” However, this crude quantification of ordinal variables further distorts the self-reporting of states.

Second, the differences between the different scores are not meaningful, which is a problem for researchers treating them as continuous variables. For instance, if a state receives

four in a single indicator, what does that figure represent? If they received three in the previous reporting cycle for that indicator, does that indicate progress? It might, but it might not. The problem is that if a change occurs over time, it is difficult to determine whether that is the product of improved DRR practices, or a change in how they interpreted the indicators. If one wishes to aggregate the indicators into an index, measures of actors' performance in DRR become even more problematic.

Third, definitions of the different levels in the indicators are poor. The process of evaluating one's own achievements in DRR are further complicated through the process of self-assessment using indicators that are too broad for use. There are many moving parts in the indicators in the exemplar: from achievement of the ill-defined goal, to levels of commitment, financial capacity, operational capacity, and the extent of planning (UNISDR, 2008: 10). If this is the case in the model example, it is difficult to know how evaluators might interpret the indicators where there is even less guidance. Separating each aspect into different indicators of progress would make more sense, allowing for a better evaluation of each aspect. As it stands now, these particular ordinal scales are impractical for any meaningful comparative analysis.

4.3. Construct Validity

A third problem with the current measurement of DRR is construct validity because the theoretical construct is distinct from the indicators. While natural disasters are certainly multidimensional and scholars should consider many factors, the primary objectives of DRR are to reduce the loss of life and limit the damage caused by natural disasters in areas of vulnerability. However, the indicators of progress feature contingencies that could alter the focus of DRR efforts.

The indicators demonstrate many admirable goals, but they fail to demonstrate whether they all have equal importance in contributing to DRR, or whether some are more significant. For instance, are financial reserves and contingency planning more, less or as important than

having an early warning system for a tsunami? The priorities and the indicators all refer to broad objectives instead of providing concrete indicators of progress. Instead, Olson, Prieto and Hoberman's (2011: 62) observation that "many UN definitions appear to result from committees, where many interests and perspectives manifest" rings true. This might have allowed the passage of the HFA, but it prevents the measurement of its goals for meaningful comparative analysis.

4.4. Social Desirability Bias

A fourth critical problem with the HFA is that it states evaluate themselves. Accordingly, there are incentives to claim that a state is achieving more progress towards the aims of the HFA than it is attaining. With oversight conducted from the UN only after states have submitted their self-evaluations, there is no accountability for fraudulent claims about progress towards DRR. States that have received aid for DRR purposes have incentives to demonstrate that they have benefited from the money in order to receive more in the future.

Even if evaluators within a state wish to report honestly, they might suffer from social desirability bias because "the basic human tendency to present oneself in the best possible light can significantly distort the information gained from self-reports" (Fisher, 1993: 303). Accordingly, the "provision of socially desirable responses in self-report data may lead to spurious correlations between variables as well as the suppression or moderation of relationships between the constructs of interest" (King and Bruner, 2000: 80). This is a critical problem for the data in the HFA reports.

As such, the measures in the HFA are problematic, and might not be accurate if states misrepresent their progress towards DRR. This is possible due to the ill-defined indicators and objectives that allow for multiple interpretations of each indicator depending on what the reader considered the most important aspects. This is another critical problem with the existing measurement of DRR progress within the HFA.

4.5. Units of Analysis

A fifth, final problem with the current measurement of progress towards DRR objectives is that different levels of analysis are not included in the indicators in the HFA. Although there are many public goods that only a state or a regional authority can provide (Enia, 2013), DRR can also take place at the individual, district/suburb, municipal, or the state/province level, independent of central government. For instance, a personal survival kit might be an essential item for survival after an earthquake, but the state might not provide that, so personal preparedness is the burden of the individual. Similarly, although the state might legislate particular building codes, local authorities might inspect and enforce compliance with these measures. The HFA does not adequately describe or measure all different units of analysis for DRR, but this is a critical factor for the measurement DRR.

Enia (2013: 222) divided the indicators in the HFA into categories according to their type of good: pure public goods, impure public good, club good, or joint product goods. This is a useful way of distinguishing between types of DRR, but further work is necessary to acknowledge each jurisdiction's levels of response to natural disasters; each with their own capacities and responsibilities to prepare, and different capacities to respond. Previous policy, practices and scholarship focus on DRR at the country, the state/province/region, the municipality, and the community/suburb/district level. However, the failure to include all levels of preparation individual and response in measurements results in an incomplete assessment of DRR, especially considering the absence of individual DRR.

5. A Framework for Measuring Disaster Risk Reduction

Given the limitations of existing measures, it is important to introduce a framework for the measurement of DRR. In order to do this, it is necessary to strip DRR back to its two fundamental purposes as proposed in this paper: reducing the loss of life and the amount of

economic damage from natural disasters. This definition makes the operationalization of the concept more straightforward. However, the fact that natural disasters are rare events remains a fundamental with the measurement of the effectiveness of DRR.

As a thought experiment for research design purposes, it would be ideal if each actor faced the same magnitude of the same natural disaster each year, so that the number of people killed and the economic damage caused by each disaster for each actor are directly measured. As a result, one could make plausible conclusions about the effects of DRR measured in different communities on the loss of life and economic damage. However, the haphazard distribution of natural disasters makes it difficult to gauge DRR effectiveness, notwithstanding the conceptual and measurement issues outlined in earlier sections. As a result, it is all but impossible to measure DRR objectives according to their intended purposes.

Cutter et al. (2014) recently devised a novel approach to measuring disaster resilience at the county-level in the U.S., creating an index out of conceptually and theoretically derived variables for their Baseline Resilience Indicators for Communities measure. However, it is possible to examine the achievement of DRR initiatives across different units of analysis. Any actor vulnerable to the effects of natural disasters can be classified as having achieved specific DRR measures, having planned a course of action, having awareness of the need to achieve DRR measures, or having completed no aspect of DRR or not.³ It is useful to conceptualize DRR as an ongoing process, and introduce a set of necessary conditions as rungs along the ladder towards improved DRR. This process is a proxy indirect measure of DRR, but it does represent a significant improvement on previous measures.

For instance, the core indicators included in the HFA indicate progress. However, some indicators do not measure DRR but instead note incidental achievements associated with

³ It is important to note that natural disasters in Chile, Japan, New Zealand, and the USA have demonstrated that even the most prepared countries have experienced ongoing problems dealing with the effects and the aftermath of natural disasters. As such, the achievement of DRR measures is no guarantee of immunity from their catastrophic effects.

broader developmental objectives. Instead, it is necessary to keep the primary objectives of DRR at the forefront of any measures. Figure 2 illustrates the conceptual steps towards successfully achieving DRR outcomes. The boxes represent points on an ordinal scale of DRR, where each necessary condition must be met for progress towards the next point in the scale. The diagonal ladders between steps represent necessary inputs for an actor’s progression from one stage to the next as they pursue DRR objectives.

Figure 2. The Steps towards Achieving Disaster Risk Reduction Objectives.

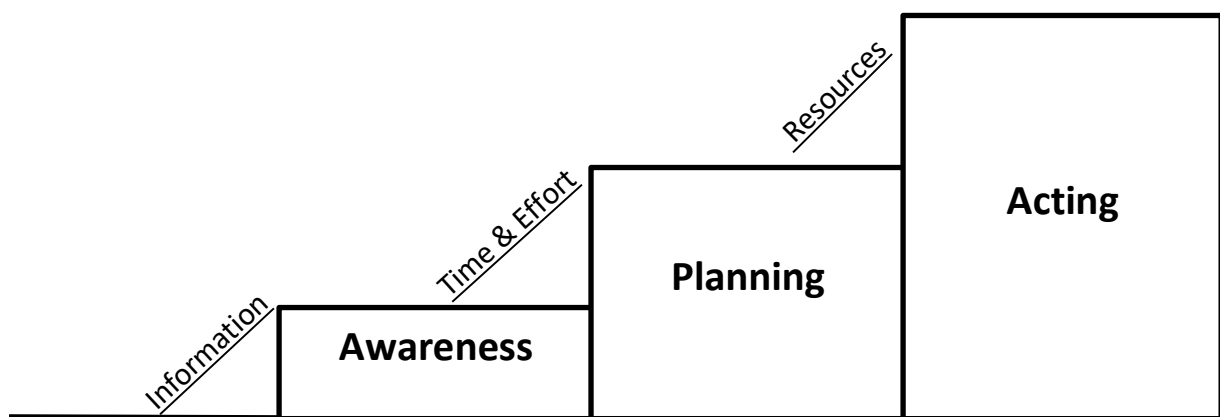


Table 2 introduces the novel framework for the measurement of DRR. The framework suggests that improvements in DRR occur through an actor receiving information about measures of DRR they can undertake to mitigate against the natural hazards they face, designing a plan for the eventuality of a disaster, and having the capacity to implement the plan. The framework consists of three necessary conditions in an ordinal scale: awareness, planning, and acting. It measures an actor’s state of preparation according to their progress along the path towards DRR. Classification occurs on a yes/no basis according to whether they have met the criteria to fulfil each necessary step in the process.⁴

⁴ One could argue that the necessary criteria identified in this framework are not necessarily discrete and separate from each other. For instance, an actor might receive information at the same time as they begin to plan. This author contends that for effective progress towards DRR objectives, an actor would have to fulfil each condition in turn, even if they might begin one stage before completing the prior step. In that case, the actor has not met the earlier condition, so they remain at that stage of the process. Another argument could be that the process is not necessarily linear – for instance, an actor might engage in action before they have completed the planning stage of the process. However, for the DRR process to be effective an actor should progress from one step to the next in this framework, or any action they take will not adequately meet intended outcomes of DRR.

Table 2. A Framework for Measuring Disaster Risk Reduction.

Code	Description of an Actor's Preparation for a Natural Disaster	Condition Met?
1	Awareness. The actor is aware of measures of disaster risk reduction to mitigate against the risks presented by a natural disaster, but they have not taken action.	Yes/No
2	Planning. The actor is aware of measures of disaster risk reduction to mitigate against the risks presented by a natural disaster, the actor has created a plan for the eventuality of a disaster, but the actor has not implemented the plan.	Yes/No
3	Acting. The actor is aware of measures of disaster risk reduction to mitigate against the risks presented by a natural disaster, the actor has created a plan for the eventuality of a disaster, and the actor has implemented the plan.	Yes/No

5.1. Awareness

Awareness is the stage where an actor is aware of the risks of a natural hazard in their area and measures of DRR they can adopt to mitigate against the effects of a natural disaster. This information could come from a variety of different outlets, and might vary according to the actor concerned. For instance, a government department might inform a country's central government about particular risks and DRR they might be able to undertake. Similarly, word of mouth, cultural practices, or social networks could inform actors about the risks they face, and particular measures of DRR to mitigate against them. It is critical that the actor must not only be aware of the hazard, but also aware of their ability to mitigate against their effects.

This is because an actor might need to be aware that they have some control over the effects of natural disasters to consider taking action to mitigate against their effects. Fundamentally, the information people receive about natural disasters might influence their pursuit of DRR. For instance, Cowan, McClure, and Wilson (2002: 182) found that "when reports portray damage as selective and refer to the lessons learned from patterns of damage, people tend to see the damage as preventable and attribute it to controllable causes." Similarly, Turner, Nigg and Paz found that "fatalism is most widespread toward the prospect of large-scale and impersonal disaster but is less prevalent when the question is personal survival or help for those at greatest risk" (1986: 422-423).

Accordingly, information about the risk of natural disasters must be “personalized,” because “personalizing risk would also personalize victimization” (Stallings, 1995: 206). Using the example of earthquakes, Stallings argues that “as human agents begin to replace nature, fate, and the luck-of-the-draw as explanations for why some people die in earthquakes and others do not, the belief that ‘nothing can be done’ becomes harder to sustain” (Stallings, 1995: 206-207). Furthermore, McClure, Sutton and Sibley argue, “Agencies should spell out to citizens that the buildings that typically suffer the worst damage in earthquakes are those that have poor building designs, whereas those that withstand earthquakes usually have good designs” (2007: 1971). As such, actors must be aware they have the ability to mitigate against the threat of the loss of life and economic damage in natural disasters to fulfil the awareness necessary condition. This information creates the conditions for further pursuit of DRR measures.

5.2. Planning

The planning stage indicates that the actor is not only informed about the risks they face in their locality, but they have also created a plan to deal with the eventuality of a natural disaster. This step necessitates considerable time and effort thinking about their own situation, their particularistic risks, and their ability to mitigate against the effects of a natural disaster. Information and being aware of the hazards an actor faces is insufficient for action – there needs to be some thought put into preparation for each particular hazard. McClure and Paton (2013: 202) posited, “If society is to fully realize the potential return on investment that can accrue from the resources invested in comprehensive risk management...it is important that this planning adopts a correspondingly comprehensive approach.” This comprehensive aspect is a fundamental requirement for the fulfilment of this necessary condition in the process towards DRR.

This planning stage involves the construction of a plan designed to mitigate against the effects of the particular hazard to limit the loss of life and economic damage from a future disaster event. The nature of the plan would likely vary across actors, as an individual would only need to secure their own environment and prepare for their individual response to the disaster, whereas a national, state, or municipal government's obligation to provide public goods might lead to different efforts to mitigate against the effects of a natural disaster.

To fulfil the necessary condition, the actor has designed a plan for what they would need to do to prepare and respond to a natural disaster. After DRR improvements by actors around the world, it might be useful to assess the quality of the plans, but in the current version of the framework, the mere presence of a comprehensive plan for each stage of a natural disaster constitutes meeting this necessary condition.

At the same time, a missing component at this stage might be the ability to carry out the plan as designed. An actor remains in this stage of the process towards DRR if they have not yet completed the requirements of the plan, or if they were unable to enact the plan with the resources available to them at the time. As such, some assistance from governmental authorities or aid might help transition from the planning stage to the acting stage in this framework. An actor might be able to provide a budget to prospective donors after having completed the necessary planning. If the planning stage was a necessary condition for funding, it is possible that DRR aid will be more effective in achieving its intended aims.

5.3. Acting

Acting is the final stage in the framework is action. This stage indicates the point where the actor has become informed about their particular vulnerabilities, they have designed a plan for the eventuality of the natural disaster/s for which they are at risk, and they have implemented the plan. This is the final stage, and perhaps the most difficult one, because it requires a significant amount of money to prepare for natural disasters adequately. In a world of scarce

resources, people might be averse to spending money on preparing for the event of a natural disaster when there are immediate concerns that demand attention, even in at-risk communities. As such, the planning and awareness stages are insufficient by themselves. Accordingly, taking costly measures towards DRR is the final stage of this framework.

As a result, “knowing one’s risk and knowing what to do, how to do it, and being able to do it are not the same” (Paton and McClure, 2013: 200). This is especially problematic for actors with plans in place, but who are unable to make further progress due to limited resources. However, foreign aid or external funding could be a way of addressing these shortfalls.

Critically, the likely effects of each stage in the framework increase the likelihood of achieving better DRR outcomes as one progresses from one level to the next. For instance, having a fully realized plan is more likely to protect citizens from natural disasters than if one only had a plan but no capacity to carry it out, but that is preferable to having no plan but being aware of the risks of natural disasters, which is preferable to ignorance about the situation. The framework is consistent with the goals of foreign aid towards DRR and it presents a better indication of progress resulting from the donations and efforts of states and NGOs than existing measures of DRR success.⁵

The framework allows the dichotomous assessment of each different stage in the ordinal scale. Similar to the measures of democracy put forward by Przeworski et al. (2000), it involves the binary measurement to indicate the fulfilment of each necessary condition. This allows for clearer evaluations of progress, and there is less room for social desirability bias on the part of states in reporting what they have achieved towards DRR improvements.⁶ This is

⁵ The author anticipates that changes in the achievement of DRR goals will be most apparent at the lower levels of the framework. If an actor becomes aware about the risks they face and they formulate a plan, this is significant progress towards the mitigation of the risks of natural disasters irrespective of the quality of the plan. Without this preparation and planning on the part of the recipient, I contend that DRR is likely to be unsuccessful.

⁶ In time, if DRR efforts improve as more actors meet the acting condition and data collection improves; it could be necessary to introduce a measure of quality of DRR. This measure could include continuous measures of quality of DRR for more fine-grained analysis of progress towards DRR. However, having actors achieve action remains the most pressing need at the present.

especially true if external experts are able to review progress at each unit of analysis, removing the necessity of self-reporting of progress towards DRR outcomes.

6. The Application of the Conceptual Framework for Disaster Risk Reduction

There are several benefits of this new conceptual procedural framework for the assessment of DRR outcomes in at-risk communities. Most importantly, the framework provides a minimalist, procedural alternative to existing measures of DRR, allowing for the comparative assessment of DRR. This is especially useful given the two different goals of DRR, the different temporal stages of any natural disaster, and the different units of analysis necessary for the integrated measurement of DRR within any given state. *6.1. Different Objectives of Disaster Risk Reduction*

This paper defined disaster risk reduction as actions intended to reduce the loss of life and the economic damage from natural disasters. Often, measures taken towards one of these two aspects of DRR effectively support both aims, but sometimes they diverge. For instance, a levy built to keep out water during floods might both save lives and reduce economic damage from a natural disaster. As such, the initiative might fulfil both objectives of DRR.

However, the design of building codes for construction in earthquake-prone mandate that a building stays up long enough for the safe evacuation of its inhabitants, but these codes might not reduce economic damage. For instance, Paulay and Priestley (1992: 10) posited that in “modern seismic design strategies, very strong emphasis is placed on the criterion that loss of life should be prevented even during the strongest ground shaking feasible for the site.” However, “extensive damage to both the structure and building contents, resulting from such severe but rare events, will have to be accepted” (Paulay and Priestley, 1992: 10). There is no expectation that these buildings will be habitable after an earthquake – the focus is instead on saving people’s lives. These types of measure would fulfil the first objective of DRR, but not

the second. Accordingly, the framework is equally applicable to both objectives of DRR separately. This helps the evaluation of actions taken towards divergent DRR objectives according to their intended outcomes.

6.2. Different Units of Analysis

As mentioned earlier, this framework applies to DRR at any unit of analysis. However, the framework is particularly valuable in providing a means to measure DRR at the individual level. This is a significant addition to the literature, allowing for the measurement of individual responses to DRR initiatives. First, individual DRR can have significant effects on people's likelihood of survival after natural disasters, especially if rescue and recovery teams take days to reach victims. Second, governments have less control over the data collection for individual disaster risk reduction considering it is much more difficult to manipulate the data, massage the findings, and present themselves in the best light.

Third, individuals also have less to gain than governments from disaster risk reduction. If funding depends on DRR outcomes, states might face incentives to misrepresent the success of their efforts. Individuals are less susceptible to such manipulation. Finally, data collection among individuals does not suffer from staff turnover, isomorphism of institutions, or a lack of knowledge sharing by government organizations that could all contribute to difficulties with data collection. This is a significant improvement to existing state-centric models of assessment because it takes into account the fact that DRR consists of a mixture of public and private goods, and individuals and governments face different challenges in preparing for the event of a natural disaster.

This framework allows for the comparative assessment of DRR initiatives across different units of analysis – allowing for comparisons across place and time. This creates the ability for policymakers, practitioners, and scholars to determine the effects of DRR initiatives on different units of analysis. This opens up a whole set of new possible cases for researchers

to evaluate the effects of DRR aid on different units of analysis, encouraging improved causal knowledge about the effectiveness of DRR aid on its intended outcomes. However, the next section applies the framework to individual disaster risk reduction only to demonstrate the usefulness of the proposed measures of DRR at that unit of analysis.

7. Individual Disaster Risk Reduction in California

California is the most populous state in the US, and if it were a country, it would be the sixth largest economy in the world (Vekshin 2016). It has endured major earthquakes in recent memory in Loma Prieta in 1989 and Northridge in 1994, and it is also vulnerable to future earthquakes, as “the probability that a major earthquake will hit in some part of California in the next 30 years is over 95 percent.” (OES, CGS 2004 Statewide Multi-hazard Mitigation Plan). The World Bank described its efforts to implement DRR as an example for other states to follow:

It has learned many lessons from its own experiences. It has been developing a system to enable the state to effectively cope with natural disasters, particularly earthquakes. Seismic risk maps for California, produced by United States Geological Survey and other organizations, have informed state and local government preparedness and response plans. These data help the local government determine where its actions and investments should be focused to reduce future earthquake losses.

Californians routinely demonstrate an awareness about the seismic risks they face in the state. California formed a public insurance agency that provides insurance to its clients against earthquake damage up to \$12 billion, and over 15 percent of the population holds policies with the insurer (California Earthquake Authority 2016). The California ShakeOut earthquake drill run by the Southern California Earthquake Center is set to have over 8.7 million participants in 2016 (ShakeOut 2016). In short, California is widely considered one of the best-prepared places for disaster risk reduction according to available metrics. As a result,

public awareness of seismic risks, participation in statewide programs and the wealth of the state should contribute towards California having widespread individual disaster risk reduction.

7.1. Survey Design

To measure individual disaster risk reduction, the author conducted a survey embedded in an online survey experiment from 30 June-18 July 2016 on residents of California aged 18 years and older, recruited through the Amazon Mechanical Turk (mTurk) website.⁷ The survey required participants to provide some demographic information, and to indicate their own preparedness for earthquakes in California. Participants received a brief introduction that reminded them that California is particularly vulnerable to the effects of earthquakes.

Participants indicated their own level of preparedness for earthquakes according to five different indicators adapted from the Southern California Earthquake Center's 'Seven Steps to Earthquake Safety.' The different indicators included 1) the identification and prevention of potential hazards in the home; 2) the formation of a strategy about what to do during an earthquake; 3) the assembly of a personal disaster supplies kit; 4) the assembly of a household disaster supplies kit; and 5) the identification and mitigation against their building's potential weaknesses. Participants reported their answers as one of the following options: 1) I was not aware of the need to take this action [Not Aware]; 2) I am aware of the need to take this action, but I have not yet completed it [Awareness]; 3) I have formed a plan to take this action, but I have not yet completed it [Planning]; or 4) I have completed this action [Acting].

7.2. Sample

The author recruited 602 participants for the study through Amazon mTurk. The sample was limited to residents in California, but they are not a representative sample of the entire population. Appendix B reports comparisons between the survey sample and the Californian population, demonstrating that participants in the sample are more educated, more politically

⁷ Appendix A provides further details of the survey design.

liberal, and less religious than the greater Californian public. However, they remain a useful sample as previous research demonstrates mTurk workers behave more representatively of the U.S. population than in-person convenience samples such as undergraduate subject pools (Berinsky et al. 2012; Huff and Tingley 2015). Participants received \$1.00 for participating in the survey experiment, paid in a single instalment after they complete the online survey, which took an average of 10-12 minutes to complete.

7.3. Results

Table 3 presents results from the survey. As is evident in the table, participants in the survey generally scored relatively poorly according to the measures proposed in the framework. Across all five indicators of DRR in the survey, the modal extent of individual DRR was that people were aware of the risks presented by the hazard and about the measure of DRR to mitigate against the risk, but they had not yet taken any further action towards its attainment. At the same time, approximately one fifth of the sample had completed each step, with the notable exception of the identification and prevention of their building’s potential weaknesses.

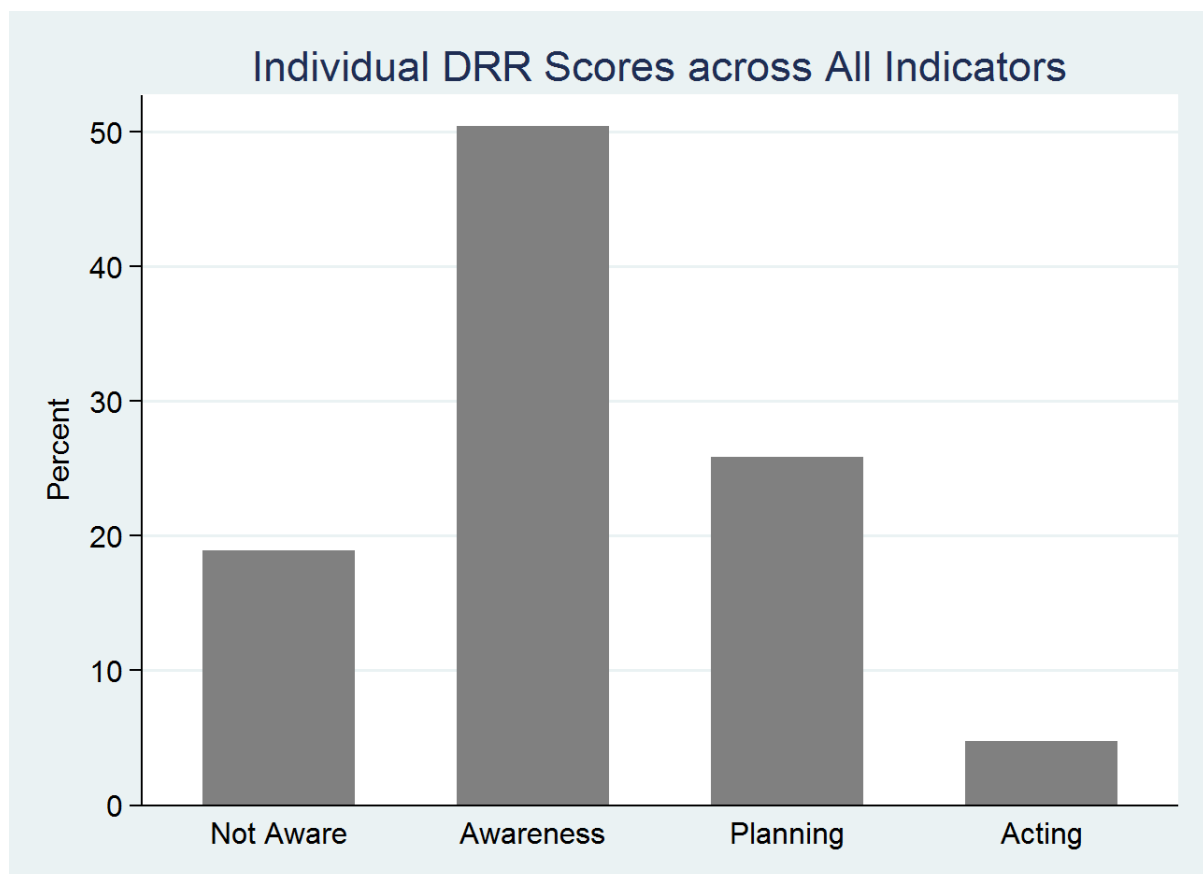
Table 3. Individual Disaster Risk Reduction in the California Survey by Indicator.

	Not Aware	Awareness	Planning	Acting
<i>Identification and Prevention of Hazards in the Home</i>	12.86%	46.10%	20.09%	20.95%
<i>Strategy about what to do during an Earthquake</i>	7.66%	40.46%	26.88%	25.00%
<i>Personal disaster supplies kit</i>	8.09%	46.39%	22.69%	22.83%
<i>Household disaster supplies kit</i>	8.24%	47.83%	20.81%	23.12%
<i>Identification and Prevention of Building’s Potential Weaknesses</i>	30.92%	41.91%	14.31%	12.86%

Aggregate measures of individual DRR across all five indicators reveal an even more troubling picture. To determine the amount of individual DRR across all indicators, the author

took the average of participants' scores, using each completed necessary condition to indicate their level of DRR. Figure 3 reports these results. Almost one fifth of the sample (18.93%) had not become aware of all five indicators of individual DRR. Over half of the population (50.43%) had not proceeded beyond the awareness stage across all five indicators, providing the mode amount of DRR among the people in the survey. Just over one quarter of the sample (25.87%), had planned to adopt every measure of individual DRR, and only 4.77% had completed all five measures of DRR.

Figure 3. Individual Disaster Risk Reduction in the California Survey across All Indicators.



Overall, the results demonstrate the usefulness of the measures of the framework, especially at the individual level. Despite California's extreme wealth, its first-hand experience of major earthquakes, and its high awareness of the risks presented by earthquakes, the sample revealed troubling amounts of individual DRR. This is particularly surprising given the wealth of the state, and the highly educated sample.

The results lend support for the utility of the framework for the measurement of DRR proposed in this paper. The minimalist operationalization of the process of DRR allows one to interpret the results using the binary measures of each stage of DRR, while the survey design ensures construct validity better than other measures of DRR. The results from the application of the framework demonstrate that there remains work to do to ensure that people prepare for earthquakes in California, despite the widespread awareness of the seismic risks faced by residents of the state. This measurement of individual DRR allows for comparisons across time and space to allow the assessment of the efficacy of DRR measures in California.

8. Policy Implications

In addition to providing an alternative way of measuring progress towards DRR objectives for researchers, the framework introduced in this paper has several policy implications. First, when applied, the framework could allow for better measurement of DRR aid outcomes for funding organizations. This is especially apparent in its application to individual DRR. Future studies should examine how different aid communities conceive of success in terms of DRR, and adapt the model to fit their purposes. Currently, it is difficult to establish the effects of any spending on DRR, especially given the problems with measuring these effects as outlined earlier. The application of the framework might allow for better testing of DRR aid's effectiveness in comparative research.

In particular, the framework helps to address the problem that aid is subject to politics. Measurement of individual DRR affords providers of aid the ability to bypass government to measure the effectiveness of their policies without government interference. However, it is also important to see how the framework matches with practices in the field and aid organizations could prefer alternative measures of DRR. The author hopes that this paper marks the beginning of a discussion about how to measure DRR at least, providing some guidance for NGOs and

aid providers if they wish to adopt minimalist measures of DRR to assess the efficacy of their efforts.

Second, if implemented, the framework could help create the platform for an incentivized funding structure for DRR, especially for international organizations such as the UNDP, the World Bank, or countries providing aid for DRR. Donors could use these measures to ensure their money helps achieve their objectives. An actor could be required to supply a plan as part of an application for funding, demonstrating need and a plan for spending it in the pursuit of DRR. If an actor has not reached the planning stage, experts in the field could help them create plans to mitigate against their hazards. This could create better efficiency in the application of DRR aid, and possibly provide a model for other aid initiatives.

Third, the framework allows for the independent audit of an actor's progress towards the implementation of DRR initiatives. Problems of self-reporting and the prospect of social desirability bias are difficult to resolve, but the framework helps address them, especially at the individual level. Anonymous individual-level surveys help reduce the chance of social desirability bias because the researcher will not know who conducted the survey. Organizations can collaborate with researchers to collect this data. While longitudinal surveys of individuals are ideal, repeat probability samples still provide researchers the ability to make inferences about individual DRR over time across populations of interest. The framework enables the comparison of actor's states of preparedness across time, and actor-year data is possible as a result. This represents a significant improvement on existing measures of DRR.

Yet caution is necessary. Although the framework applies very well to individual-level analysis, issues about implementation remain at higher levels of analysis. Problems regarding incentives to misrepresent data remain, even if the measures themselves represent an improvement on the HFA. Future research should further examine the application of the framework to units of analysis such as the district/suburb, municipality, state/province, and

national level. Although this assessment is more complex regarding the fulfilment of the necessary conditions, aid practitioners, scholars, NGOs, and those most familiar with DRR implementation at the local level could assess DRR at greater levels of analysis than the individual.

Ultimately, the framework could lead to changes in the provision of funding for DRR. An important missing component of acting is actors' ability to carry out the plan as designed. An actor remains in this stage of the process towards DRR if they have not yet completed the requirements of the plan, or if they were unable to enact the plan with the resources available to them at the time. As such, some assistance from governmental authorities or aid might help transition from the planning stage to the acting stage in this framework. An actor might be able to provide a budget to prospective donors after having completed the necessary planning. If the planning stage was a necessary condition for funding, it is possible that DRR aid will be more effective in achieving its intended aims. With better measures and improved operationalization of DRR, such assessment might be possible.

9. Conclusion

This paper proposed a framework for the replicable measurement of progress towards DRR initiatives by actors vulnerable to natural disasters. Although disaster risk reduction was the focus of this paper, it is possible that similar frameworks are possible for other forms of foreign aid. At the very least, the author hopes that this marks the start of a discussion about how to measure aid effectiveness in domains where the direct measurement of intended outcomes is impossible. The framework represents an improvement on existing measures of DRR, and the author hopes that it will open up multiple possibilities for future research. The results of the individual DRR demonstrate the utility of the framework at that level, but further work is necessary to adapt the framework for implementation at greater levels of analysis.

The framework could allow the adoption of multiple methods for the study of DRR. In-depth qualitative case studies have developed tremendous insights into the improvement of DRR in at-risk communities. Other methodological tools could complement this research to advance knowledge about DRR. In particular, randomized field experiments have been largely absent from the area of DRR, perhaps because of the opaque nature of the dependent variable. Systematic quantitative analysis using existing datasets like AidData (Tierney et al., 2011) allow for the use of DRR aid as an independent variable, and there are exciting possibilities for the development of datasets using the framework. Furthermore, survey research using probability samples could adopt the framework to develop indicators of DRR at the individual level.

An important future research agenda lies ahead as natural disasters become ever more of a threat as climate change, urbanization and overpopulation increase the vulnerabilities of at-risk communities all around the world. It is the author's hope that this framework is a start towards the better conceptualization and measurement of the effectiveness of foreign aid spent on initiatives to save lives and reduce economic damage from natural disasters.

Appendix A. Survey Design.

1. Please enter your age.
2. In which state do you live?
3. What is the zipcode where you live?
4. What is the highest level of school you have completed?
 - No formal education
 - 1st, 2nd, 3rd, or 4th grade
 - 5th or 6th grade
 - 7th or 8th grade
 - 9th grade
 - 10th grade
 - 11th grade
 - 12th grade, no diploma
 - High School Graduate – High School Diploma or the equivalent
 - Some college, no degree
 - Associate degree
 - Bachelor's degree
 - Master's degree
 - Professional or Doctorate degree
5. Please indicate what you consider your racial background to be. We greatly appreciate your effort to describe your background using the standard categories provided. These race categories may not fully describe you, but they do match those used by the Census bureau. It helps us compare our survey respondents to the U.S. population.

Please check one or more categories below to indicate what race(s) you consider yourself to be.

- White
- Black or African American
- American Indian or Alaska Native – Type in name of enrolled or principal tribe
- Asian Indian
- Chinese
- Filipino
- Japanese
- Korean
- Vietnamese
- Other Asian – type in race
- Native Hawaiian
- Guamanian or Chamorro
- Samoan
- Other Pacific Islander – Type in race

- Some other race – Type in race
6. What is your gender?
- Male
 - Female
7. The next question is about the total income of YOUR HOUSEHOLD for the PAST 12 MONTHS. Please include your income PLUS the income of all members living in your household (including cohabiting partners and armed force members living at home). Please count income BEFORE TAXES and from all sources (such as wages, salaries, tips, net income from a business, interest, dividends, child support, alimony, and Social Security, public assistance, pensions, or retirement benefits).
- Less than \$10,000 (1)
 - \$10,000 to \$19,999 (2)
 - \$20,000 to \$29,999 (3)
 - \$30,000 to \$39,999 (4)
 - \$40,000 to \$49,999 (5)
 - \$50,000 to \$59,999 (6)
 - \$60,000 to \$69,999 (7)
 - \$70,000 to \$79,999 (8)
 - \$80,000 to \$89,999 (9)
 - \$90,000 to \$99,999 (10)
 - \$100,000 to \$149,999 (11)
 - More than \$150,000 (12)
8. Are you now married, widowed, divorced, separated, never married, or living with a partner?
- Married (1)
 - Widowed (2)
 - Divorced (3)
 - Separated (4)
 - Never married (5)
 - Living with partner (6)
9. Are your living quarters...
- Owned or being bought by you or someone in your household (1)
 - Rented for cash (2)
 - Occupied without payment of cash rent (3)
10. Which statement best describes your current employment status?
- Working - as a paid employee (1)
 - Working - self-employed (2)
 - Not working - on temporary layoff from a job (3)
 - Not working - looking for work (4)

- Not working - retired (5)
- Not working - disabled (6)
- Not working - other (7)

11. Generally speaking, do you think of yourself as a...

- Republican (1)
- Democrat (2)
- Independent (3)
- Another party, please specify: (4) _____
- No preference (5)

12. Answer If Generally speaking, do you think of yourself as a... Republican Is Selected

Would you call yourself a...

- Strong Republican (1)
- Not very strong Republican (2)

13. Answer If Generally speaking, do you think of yourself as a... Democrat Is Selected

Would you call yourself a...

- Strong democrat (1)
- Not very strong Democrat (2)

14. Answer If Generally speaking, do you think of yourself as a... Independent Is Selected
And Generally speaking, do you think of yourself as a... Another party, please specify: Is Selected
And Generally speaking, do you think of yourself as a... No preference Is Selected

Do you think of yourself as closer to the...

- Republican Party (1)
- Democratic Party (2)

15. In general, do you think of yourself as...

- Extremely liberal (1)
- Liberal (2)
- Slightly liberal (3)
- Moderate, middle of the road (4)
- Slightly conservative (5)
- Conservative (6)
- Extremely conservative (7)

16. What is your religion?

- Baptist - any denomination (1)
- Protestant (e.g. Methodist, Lutheran, Presbyterian, Episcopal) (2)

- Catholic (3)
- Mormon (4)
- Jewish (5)
- Muslim (6)
- Hindu (7)
- Buddhist (8)
- Pentecostal (9)
- Eastern Orthodox (10)
- Other Christian (11)
- Other non-Christian (12)
- None (13)

17. How often do you attend religious services?

- More than once a week (1)
- Once a week (2)
- Once or twice a month (3)
- A few times a year (4)
- Once a year or less (5)
- Never (6)

Survey Questions about Individual DRR Measures

As mentioned earlier, California is considered to be particularly vulnerable to the effects of earthquakes as the state lies on active faults that can create frequent and destructive earthquakes.

18. You are now asked to indicate your **OWN** level of preparedness for the event of an earthquake in terms of **potential hazards in your home**.

	I was not aware of the need to take this action	I am aware of the need to take this action, but I have not yet completed it	I have formed a plan to take this action, but I have not yet completed it	I have completed this action
I have identified and prevented potential hazards in my home				

19. You are now asked to indicate your **OWN** level of preparedness for the event of an earthquake in terms of **a strategy during an earthquake**.

	I was not aware of the need to take this action	I am aware of the need to take this action, but I have not yet completed it	I have formed a plan to take this action, but I have not yet completed it	I have completed this action
I have formed a strategy about what to do during an earthquake				

20. You are now asked to indicate your **OWN** level of preparedness for the event of an earthquake in terms of **a personal disaster supplies kit**.

	I was not aware of the need to take this action	I am aware of the need to take this action, but I have not yet completed it	I have formed a plan to take this action, but I have not yet completed it	I have completed this action
I have assembled a personal disaster supplies kit				

21. You are now asked to indicate your **OWN** level of preparedness for the event of an earthquake in terms of **a household disaster supplies kit**.

	I was not aware of the need to take this action	I am aware of the need to take this action, but I have not yet completed it	I have formed a plan to take this action, but I have not yet completed it	I have completed this action
I have assembled a household disaster supplies kit				

22. You are now asked to indicate your **OWN** level of preparedness for the event of an earthquake in terms of your **building's potential weaknesses**.

	I was not aware of the need to take this action	I am aware of the need to take this action, but I have not yet completed it	I have formed a plan to take this action, but I have not yet completed it	I have completed this action
I have identified and acted to mitigate against my building's potential weaknesses				

Appendix B. Comparisons between the Survey Sample and the Californian Population.

Table 4. Comparisons of Demographic Characteristics between the mTurk Sample and the Californian Population.

Variable	California Population Census, July 1 2015	mTurk Sample
Age		
Persons under 5 years	6.4%	0%
Persons under 18 years	23.3%	0%
Persons 65 years and over	13.3%	2.02%
Female Persons	50.3%	49.13%
Education		
High school graduate or higher	81.5%#	99.13%
Bachelor's degree or higher	31.0%#	53.18%
Median Household Income	\$61,489	\$40,000-\$49,000
Employment		
Employed in civilian labor force	63.4%	76.16%
Race & Ethnicity		
White	72.9%*	67.20%
Black/African American	6.5%*	8.24%
American Indian/Native American	1.7%*	1.59%
Asian	14.7%*	23.84%
Hispanic or Latino	38.8%+	6.07%
White alone, not Hispanic or Latino	38.0%	N/A
Living in Own Home	54.8%	42.92%

Percent of persons aged 25 years and older

* Includes persons reporting only one race or ethnicity

+ People Hispanic or Latino people may be of any race, so also are included in applicable race categories

Table 5. Comparisons of Party ID between the mTurk Sample and the Californian Population.

Variable	California Voter Registration Data, May 2016	mTurk Sample
Republican Party	27.3%	15.17%
Democratic Party	44.8%	49.86%
Independent	23.3%	27.75%
Other Party/No preference	-	7.23%

Table 6. Comparisons of Religious Identity and Religious Attendance between the mTurk Sample and the Californian Population in Religion.

Variable	Pew Religious Landscape Survey	mTurk Sample
<i>Religious Attendance</i>		
At least once a week	31%	12.14%
Once or twice a month/ A few times a year	35%	18.78%
Seldom/Never	34%	69.08%
<i>Religion</i>		
Baptist	6%	2.75%
Protestant	21%	9.97%
Catholic	28%	15.90%
Mormon	1%	0.43%
Jewish	2%	1.73%
Muslim	1%	1.01%
Hindu	2%	0.58%
Buddhist	2%	3.03%
Pentecostal	5%	0.87%
Eastern Orthodox	1%	0.72%
Other Christian	1%	10.98%
Other non-Christian	2%	2.60%
None	45%	49.42%

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