Indicator Issues and Proposed Framework for a Disaster Preparedness Index (DPi)

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DRAFT

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Summary

Based on the current state of practice, this paper examines the issues in measuring disaster preparedness, and the process of constructing indicators and indices. Existing indices are examined, and a proposed framework of creating a Disaster Preparedness Index (DPi), and Resiliency Index (Ri) with a suggested list of measurement indicators is put forward. The framework and indicator list is unweighted, and as with any existing index, the weighting of the components are a subjective process, and are adjusted based on expert panel review or iterative on-ground application and review.

Introduction

Recent catastrophic events have created a greater awareness for disaster preparedness across all sectors, public to private. There have been efforts to measure aspects of disaster including preparedness, resilience, mitigation efforts, social vulnerability, and hazard exposure. There are potential benefits from measuring disaster related themes, such as a clearer understanding of community preparedness, and providing a means to encourage communities that are more vulnerable and less prepared to improve their preparedness efforts. Better measurement may also lead to a more efficient allocation of scarce resources, and assist in the pricing of risk more effectively and accurately. The creation and use of an “index” has been a popular methodology for evaluating relative levels of some state of being, whether economic health, quality of life, or something similar. In some cases, there have been indices that attempt to capture levels of social vulnerability to natural hazards. Indices are usually comprised of a set of indicators and through some mathematical combinations an index number is derived for a community which can be used to make comparisons with other communities.

The Language of Indices

An index is a composite representation of numerical measurements, manipulated in some manner to give a single value, often called an “index score” or rank. Terminology in this area that is often used to discuss the creation, measurement and comparison of concepts such as:

1. data: information organized for analysis, reasoning or decision-making
2. indicator: value or group of values that give an indication or direction
3. metric: a standard of measurement
4. index: number derived from a series of observations, used as an indicator

A classical definition of an index number can be described as a statistical value that is modified, and its variations signify a change of magnitude, but are not subject to accurate measurement that would not be easily observed and has the influence to affect the values (Edgeworth, 1925b). Index numbers were originally developed by economists for measuring commodities prices, and to gage the average percentage change from one period in time to another. While the commodities approach and its particular definition of index numbers has been directed towards prices, it has also been applied to other themes with differential values. These applications have involved such comparisons as those between two geographical places or comparisons between the magnitudes of a group of elements under any one set of circumstances (Fisher, 1967). Many of the efforts to define and quantify preparedness still remain unsatisfactory (Kirschenbuam, 2002). As the perceived value and possible applications has risen, their use has spread to fields outside of economics and into the social sciences.

Methodological Issues

There are a number of issues that arise when attempting to create disaster preparedness measures and indices. Potential problems that may arise include subjectivity, bias, weighting, mathematical combinations, selection of indicators, and source of the data. The following discussion is based on a review of the current literature within the field. After the discussion there is a comparison of several major indices, providing a breakdown of their structure and approach.

Indices have become more widely applied in social capital and capacities, and measure such things as quality of life (QOL), human development, and social vulnerability. An index will usually be composed of several different indicators that relate to the quality of life, human development, vulnerability, emergency preparedness or what ever the topic of the index might be. These indicators tend to be socially constructed and are used in indices that measure conditions and changes over time, for different populations (Land, 1983). Social indicators and monitoring social phenomena became widely used by social scientist and policy makers beginning in the 1960's (Sheldon and Parke, 1975).

Indices are attractive because of their ability to summarize a considerable amount of technical information in a way that is easy for lay persons to understand (Davidson, Lambert, 2001). Some indexes, such as the United Nations Human Development Index (HDI), do not provide the entire picture, but they are more beneficial then just examining one indicator such as income because they will incorporate into the index other variables, such as education and health (United Nations, 2005). By examining multiple indicators, the level of bias can be reduced and the picture that is provided by investigating just one indicator is much clearer, providing a wider perspective (Cobb and Rixford, 1998). This is an especially useful feature for the emergency preparedness community—bringing together a wide array of professionals. Indices are also very attractive to the policy community because they provide a set a metrics that allow for comparison of vulnerability between different communities (Cutter, 2003).

Vulnerability can only be measured with a clear definition that can be operationalized. Blaikie et al define vulnerability as “the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard” (Blaikie et al, 1994, pg9). These indicators provide a way of specifying discrepancies between present and desired circumstances (Innes, 1975). In the case of disaster preparedness or human vulnerability the goal for communities is to maximize their preparedness potential and minimized their vulnerability.

This report summarizes many of the problems and issues that are associated with indexes constructed for vulnerability and hazards. Several indices related to hazards and vulnerability are compared and a breakdown of each index provided. The breakdown generally includes a formula, items measured, methodology, variables, scope and an example of empirical proofs.

What is on the inside of an Index?

Indexes are generally constructed by the summing or multiplying of several indicators relating to item being measured. Indicators that go into creating an index will have different units such as dollars, miles, degrees, population per square mile, or similar. Various methods are used, such scaling, to create “unit-less” variables. For example, a linear method of scaling was used for the Hurricane Disaster Risk Index (Davidson, Lambert, 2001) and the Earthquake Disaster Risk Index (Davidson and Shaw, 1997). Data can also be standardized and made unit-less by using Z-scores and then summing the values-- a method used for the Social Flood Vulnerability Index (Cutter 1999).

Other mathematical procedures, such as weighting techniques, are also incorporated into an index value in order to identify the varying levels of importance for each indicator. Weighting is a subjective process, and indicators that are considered to be of utmost importance to the index, can be assigned a higher “weight” to indicate the importance of the specific indicator (Ksly, Briguglio, McLeod, Schmall, Pratt, and Pal, Environmental Vulnerability Index, 1999).

Issues of Validation

Once an index number has been derived, there are several questions that should be asked. One considerable shortcoming of using composite indexes is that there is no simple way to get scientific validation of a particular index (Davidson, Shah, 1997). The absence of validation is a major concern. In many circumstances, the index relies on empirical data that is far from being perfect. It is assumed by many users of the information that just because some numbers have been derived, it is a valid and reliable method. There are, however, some methods that can be used to help validate the index. Qualitative techniques such as conducting in-depth surveys or cases studies could be perform to assess the reliability of data (Munich Re, 2002).

Indicators are reified snapshots

Another key issue to consider with indices is that an index takes a group of indicators and produces a snapshot of reality. Indices are quantitative subjective measures, acting as proxies for the concept under examination (Cobb, 2000). As indices are proxy measures, they also do not represent the true nature of a hazard or vulnerability. Cobb and Rixford (1998: 20) stated that "every indicator is a flawed representative of a complex set of events." Indices are unitless and the arithmetic is considered to be odd because in most cases the values do not represent anything outside of the context in which the situation is being compared. Contextual representation means an index number measuring the magnitude of a hazard or vulnerability is not on a linear scale, as a score of 5 on an index does not represent twice the vulnerability compared to score of 10 (Lloyd and Wilson, 2002).

Data Availability and Bias

Indexes have also been adapted and utilized by various government organizations. There has been considerable use of indices by different agencies to measure health, education, agriculture, economy, and similar socioeconomic trends (Ferriss, 1988). Different agencies within the government are also responsible for the collection of a considerable amount of data that is used to compile these indices. Not all data that government agencies collect is easily attainable (D'agostino, 1975). Data that would fall into this classification would include anything related to homeland security, which creates a problem for acquiring the data. Agency representatives and their parent organizations are often skeptical about the intentions of those who collect data. One inherent problem is the fact that there is no "correct" method for creating an indicator, and there will be opportunities for the interested parties to alter the indicator to suggest what they want it to (Innes, 1975).

Data from government sources should not be thought of as free from bias, as social indicators can and will be used to advocate particular political stances, and therefore may be imprecise because of bureaucratic wrangling (Carley, 1981). At the root, all indicator work has some political aspects, and even the act of deciding what to count is value oriented and subjective in nature (Cobb and Rixford, 1998).

Bias and the "Report Card"

Many of the bias problems found with indexes are clearly evident within a particular type: the report card grading system. In many cases the report cards are self evaluations. In other instances, the report card is an evaluation of a government organization or a policy. A primary example of the "report card approach" is found with the American Society of Civil Engineers (ASCE) "Report card for infrastructure." The issue of bias is a major concern. It is in the best interest of the civil engineers to give lower grades for infrastructure, because this translates into more work for civil engineers. Although this would be unethical, the possibility for bias is present. In the instance of a self evaluation or grading on the report card it is in the best interest to assign high marks for one's self. When employment and financial compensation are at stake it would make no sense to assign ones self with a low grade, this would make it very difficult to achieve a fair report card and grade. When a specific group is grading a government organization they usually have different ideological backgrounds. This adds to the controversy about indicators and indices as they are used in making public decisions, but represents particular perspectives and theories (Innes, 1975). Governments are expected to remain neutral, but are composed of political parties that are motivated by ideologies and agencies produce indicators that subtly take sides and express ideology (Cobb, 2000). This is evident with statistics that are usually compiled by government agencies and are done so with little purpose that may represent issues in a misleading way (Innes, 1975).

Data Sources, Data Selection, and Data Availability

There are other methodological questions that should be asked when working with indices and more specifically indices that deal with hazards and vulnerability. One of the first issues that should be considered is the source of the data used to create the index. The indicators that describe and measure vulnerability are defined through the availability of these datasets will be used because the datasets are there, rather than because the data represents vulnerability (King, 2001).

Another methodological issue is based on the selection process of indicators that will go into an index. The selection of indicators can usually be accomplished in two ways. The first method is based on a theoretical approach and an understanding of the relationship of indicators, while the second method is based on an understanding of statistical relationships (Adger, Brooks, Bentham, Agnew – Tyndall Center, p.17). The theoretical approach is more comprehensive in nature. Using this technique one would decide what factors encapsulate the item measured without regard to data availability. An example of an index that used this method is the Earthquake Disaster Risk Index (EDRI). The second approach is to examine what data is available, and then select indicators based on data availability, such as the environmental vulnerability index (EVI).

Upon examination of most indexing systems, data availability is seen to be a major limitation to the creation of indicators and indexes. There are costs involved with collecting good data. Who will be willing to pay for the data collection? Or maintain it? These considerations are critical and should be taken into consideration (D'agostino, 1975). One typical source of data is from the U.S. decennial census and some common indicators that would be used to measure vulnerability might include population, age, income, education, and housing structure type. Census information may not be reliable especially for particular populations as there may not be reliable counts for undocumented workers, and similar cases of under counting. Data is more readily available for large and medium scale disaster events, which makes it more difficult to evaluate small scale and everyday disasters (UNDP, 2004). Another problem that arises with small scale analysis is with census tracts and the lack of homogeneity in size (King, 2001). Although numbers are standardized into percentages the overall raw values are lost, reducing the value of the data to emergency managers (King, 2001).

Measuring change over time is an important aspect of social study, and using time series data is an approach that can be taken (Ferris, 1988). Census information can be used for this, but a problem that arises is that census boundaries change over time—making it difficult to examine smaller areas over a period of time. City boundaries can also change over time when cities merge with counties. The ten year interval for the census may be too long to monitor changes and track patterns in a time series fashion that is representative.

Data Decay

Another time-related issue with population datasets is data decay, as any census or survey dataset becomes less accurate with the passage of time (King, 2001). Data Decay also applies to buildings as structures age, renovations occur, buildings are demolished, and changing technology and updated building codes have an effect (Davidson, Zhao and Kumar, 2003).

The dynamic nature of vulnerability also makes it difficult to quantify. Vulnerability has a time-space dimension that fluctuates according to the type of hazard (Blaikie et al, 1994). More specifically, the vulnerability of populations varies according to the time of day, day of the week, and season of the year (Davidson, Shah, 1997). Traditional datasets, such as the U.S. Census are a static snapshot of a particular moment in time, and therefore may present a picture of vulnerability that may not be complete. Take for example a college town that has a varying population depending on the time of year. Another example would be primary school in session during the day, and by using census information for a population count, this sensitive population would not be taken into consideration. By using census figures for population counts one might neglect vulnerable hospital populations which are not accounted for in census data.

Indicator Selection: Who Decides What is Important?

Once questions about the datasets have been resolved, attention is focused on the selection of variables from these datasets. In the case of vulnerability, to what extent will the variables and numbers selected for analysis represent reality (Carley, 1981)? The selection of variables that will determine vulnerability for an index is a subjective process. Data collection and the acquiring of knowledge become subjective due to differing perspectives of the world that reflect race, gender, social and cultural identities (Cutter, 2003). Communities are also unique and are influenced are many different factors such as history, politics, demographics, traditions, and similar developmental factors (Besleme, Maser and Silverstein, 1999). These variations may affect the data and indicators that are selected. What one community may view as a critical indicator may not be viewed in the same way by a different community. If an indicator is derived from survey data, there may be issues with interpretation from different communities (Besleme, Maser and Silverstein, 1999). For a variable to be a good indicator of vulnerability, there must be a clear theoretical foundation in order to measure what is intended (Dwyer, Nielsen, Day, Roberts, 2004).

There are differences in opinion in the social science community over the selection of the specific variables that represent vulnerability, such as access to resources, political power, and building supply (Cutter, Boruff, Shirley, 2003). Research in the hazards community has attempted to identify components that indicate vulnerability. Few clear measurers of vulnerability, however, have been established (Chakraborty, et al., 2005). The neglect of creating measures that quantify human vulnerability has been predominantly ignored because of the difficulties that emerging from attempting to measure social vulnerability (Cutter, Boruff, Shirley, 2003). Physical characteristics of a community such housing stock or state of the infrastructure is easier to quantify than population characteristics (King, 2001). Ease of measurement may explain why there are considerable indicators regarding physical characteristics of a community, but far fewer measurements for human and social characteristics. In many instances data may not be available, so proxy indicators have to be selected, such as the case with the United Nations Disaster Risk Index that uses mortality information because other reliable data is not available at a global level (UNDP, 2004).

Complexity and Measurement

The complexity of the issues of measuring a community's vulnerability to hazards has posed a series of problems. Hazard vulnerability can be viewed as the summation of a continuum that combines physical and social exposure, disaster resilience, preventive mitigation, and post event response (Cross, 2002). Because of this immense complexity and wide range of scope of the factors of vulnerability, it requires that data be used from multiple sources. Multiple sourcing represents another problem for data analysis, because of the variability of the data sources and the different methods used to collect them (Twigg, 2004). Another problem is that because there is a wide array of information there difficult to delve into any one particular aspect of vulnerability but rather to take a more general approach without detailed analysis (Benson and Twigg, 2004).

Another key concern arising from complexity is the interaction of the components of vulnerability in the context of multiple hazards and risk (Chakraborty, et. al., 2005). As of yet, we are unable to fully grasp the nature of interactions that take place between risk and vulnerability, and this could be related to the fact that we as a community know the least about the social aspects of vulnerability and the quantification of vulnerability (Cutter, Boruff, Shirley, 2003). The social aspects of vulnerability consist of the nature of people, social structures, and culture which inherently makes it geared towards a qualitative assessment (Dwyer, Nielsen, Roberts, 2004). Complex interactions can take place between physical and social attributes along with living arrangements. One example of a complex interaction that takes place is that of race and gender and how the combination and interaction of the two variables creates marginality associated with high risk (Morrow, 1999).

Compilation and Analysis

Once questions about the data have been resolved and decisions have been made on what variables to use, the next logical question will be how to compile the data into an index. The two main elements that comprise overall vulnerability, including social vulnerability and hazard vulnerability, are combined for two reasons. First an average of values will be more stable than a separate indicator and secondly there is a need to reduce the complexity of the data into a summary such as the Consumer Price Index (D'agostino, 1975). The integration the different vulnerabilities create methodological problems, as some combine by multiplying the two indices (hazard and social), whereas others sum the two indices (Chakraborty et al , 2005).

The Appendix to this report identifies several different indices related to hazards and vulnerability. For each, there is a breakdown of the index, pulling out the key components such as the formula, the items measured, methodology, variables, scope and empirical proofs.

Framing the Measurement: *Disaster Demands vs. Community Capacity*

One method of defining a disaster is based on the notion that a disaster is only a "disaster" if the demands created by the event exceed the community's capacity for dealing with it. Quarantelli calls this an "imbalance in the demand-capability ratio in a crisis situation" (Quarantelli 1982:464). The idea of examining formal organizations with respect to extreme stress situations can be traced back to the work of Barton (1969) and Drabek and Haas (1970). Other notable researchers have also considered the framing of a disaster as a crisis state, or social stressor.

Wenger (1978), in particular, articulated that the impact of a disaster agent is not a sufficient enough characteristic to determine a disaster has occurred. Wenger states "[i]n addition, one must consider the degree of crisis management capability in the community" (Wenger 1978:28). Because community resources, commitment to preparedness, and other factors influence the ability to respond to disaster impacts, Wenger goes on to say that:

> [I]t is possible that given two different communities, one with extensive crisis management mechanisms and the other with few such resources, disaster agents with similar characteristics may produce a crisis in the latter system, but only an emergency in the former (Wenger op cit).

While the "demands exceeding capacity" proposition makes intuitive sense, it has not thus far been operationalized or empirically tested to examine its validity. In order to create a model for the creation of a Preparedness Index and Resiliency Index (CRI), we must formulate the indicators that will allow us to test the validity of the index, as well as how best to apply it in practice.

Guiding Tenets for measurement efforts

There have been some efforts in this area, such as the understanding of social vulnerability (Cutter 2000, 2003a, 2003b) and vulnerable populations, the assessment of state and local vulnerability (Simpson 2004), the determination of community wide vulnerability (NOAA's CVAT and associated tools), and the determination of loss potential (HAZUS99 and HAZUS-MH). However, little has been done in the way of measuring resilience which is, in large part, linked to a community's preparedness. Based on research at the Center for Hazards Research, the following tenets will help frame the development of a successful index and its deployment:

1. Data should be from objective sources and reasonably accessible (not self report or by interview);
2. Index measures should be standardized and normalized to permit cross-community comparison;
3. Index and measures need a means of accepted validation;
4. There should be consensus agreement on measures and indicators, including the type, depth, scope, and appropriateness;
5. The model requires collaborative process to determine weighting and final model format; and
6. The index and measures (particularly application in the field), require practitioner support within an institutional framework.

Given the background of measurement in hazards, we offer the following framework within which the indicators and measures can be used to formulate a defensible resiliency index.

Proposed Modeling Framework

The project would use existing research and theoretical constructs to more fully understand the appropriate variables that explain variance in preparedness and resilience in any given community. Based on prior and current research conducted by the PI, we can propose a starting framework within which the indicators can be examined and developed. Various models exist to determine a community's exposure, but generically this can be described as:

$$\text{Vulnerability} = \text{hazard} * \text{probability} * \text{frequency} * \text{Vulnerability measures (VM)}$$

The Disaster Resilience Index (DRi) will be a composite result of the presumed relationship between community preparedness measures (Pi) and the derivation of a Vulnerability score. Only through testing can we determine the most appropriate mathematical relationship, but the initial working framework is that a meaningful DRi can be derived from:

$$\textbf{Disaster Resiliency Index (DRi)} = \frac{\textbf{Preparedness Index (Pi)}}{\textbf{Vulnerability (V)}}$$

Where DRi > 1, the community is more resilient
Where DRi < 1, the community is less resilient

This gives a broad indication of resilience. More detailed meaning will come from the manner in which the components are weighted, and the determination of a relative standard of resilience from which cross comparisons can be made. In effect, the Disaster Resiliency Index can be considered to be a function of a community's preparedness in a ratio to its relative exposure to a unique set of hazards in that community. The higher the Preparedness score, the higher the resiliency index. For a higher cumulative set of hazards and exposure (vulnerability), for a given level of preparedness, the lower the resiliency score.

Determining the key variables, measures and metrics

Using a collaborative and consensus-based process among identified experts in the field—the individual measures will be determined and weighted. These are identified below as functional measures of preparedness (FM), and vulnerability measures (VM).

The functional measures (FM) will be based on measuring such spatial and non-spatial data items across a range of community assets, including physical, economic, socio-cultural, and ecological dimensions of capital. The same will be true for community exposure and vulnerabilities (VM). The number of measures can be as extensive as feasible data collection and synthesis allows.

Once the measures have been determined and agreed upon, they can then be scaled and normalized to fill in the following equations, first determining the preparedness index score. First, as an overall measure of community capacity, the derivation of a preparedness (Pi) score for a given location (x) will use the following:

$$Pi_x = (w_1FM_1 + w_2FM_2 + \dots w_nFM_n) \qquad \text{Where:}$$

Pi	=	community preparedness (P) index
x	=	location of community
w_n	=	weight for a given measure
FM_n	=	functional measure/indicator
n	=	number of measures

The next step is to determine the unique vulnerability of the community (located at x), by deriving a vulnerability score that measures hazards--including frequency and probability—as well as additional vulnerability measures (such as socially vulnerable populations):

$$V_x = [(H_a p_a f_a)+(H_b p_b f_b)+\ldots] \times [(w_1 VM_1 + w_2 VM_2 + \ldots w_n VM_n)]$$

where:	V	=	Community Vulnerability
	x	=	location of community
	$H_{a,b,c\ldots}$	=	Hazard agent (earthquake, hurricane….)
	f	=	frequency of hazard
	p	=	probability of hazard
	w	=	weight
	VM	=	Vulnerability measure/indicator
	n	=	number of measures

Determining the ratio of capacity to vulnerability will give the Disaster Resiliency Index score. So that the Disaster Resiliency score will be:

$$\mathbf{DRi_x} = \frac{\mathbf{Pi_x}}{\mathbf{V_x}}$$

or

$$\text{Disaster Resiliency index} = \frac{\text{Community preparedness index}}{\text{Community vulnerability}}$$

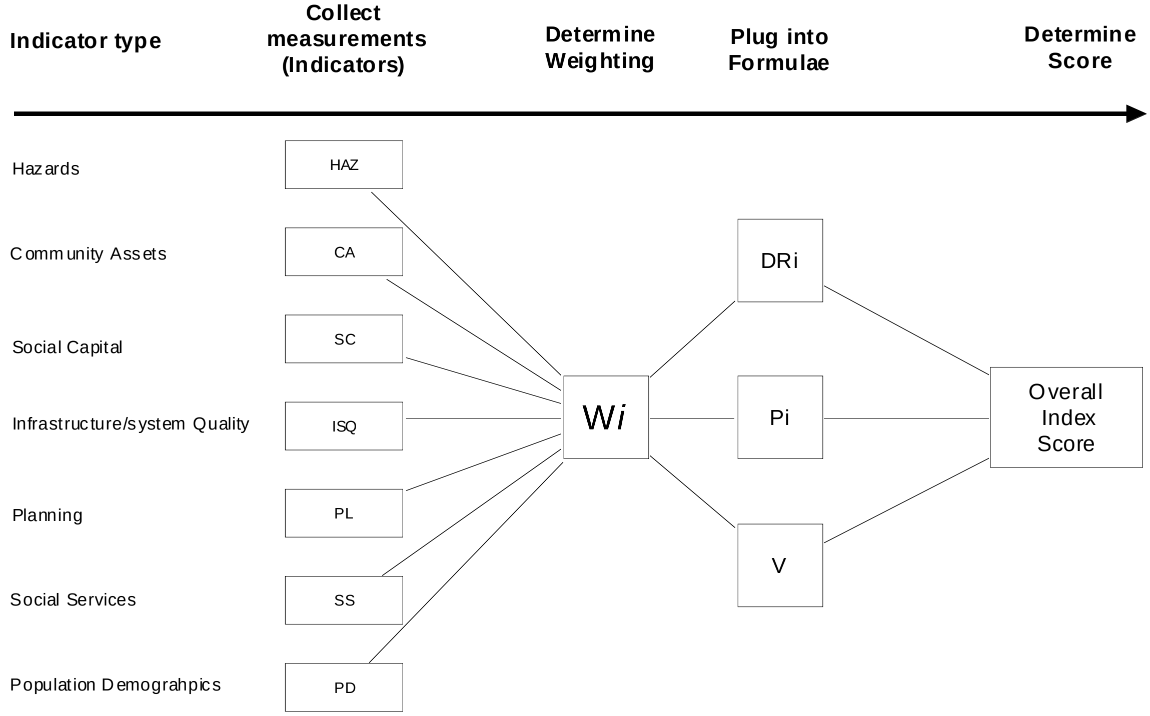
Higher resilience scores will be determined by larger community capacity (measured as preparedness) versus the amount of vulnerability, or similarly if the community has low exposure (vulnerability) it will have a higher resilience score.

While this framework provides an overall structure to the model, the key factors (weighting, indicator development, data availability) will drive validity and model robustness.

Collection and use of Indicators for Index

Conceptually, the implementation of this framework will look something like the diagram below:

Disaster Indexing
Measurement Model Diagram



Measurement indicators will be determined from a listing of indicators used in other models, to be determined by an expert panel process.

The following table lists indicators that have been used in other index systems. They are identified as being either an asset (and therefore plugging into the Preparedness, or Functional Measure part of the equation, FM, shown earlier) and forms part of the preparedness index (Pi), or a liability (Vulnerability, and therefore is part of the VM part of the equation).

Categorization Legend

HAZ - Hazards
CA - Community Assets
EA -Entitlement Accessibility
SC - Social Capital
ISQ - Infrastructure / System Quality
PL - Planning
SS - Social Services
PD - Population demographics

Possible Measurement Indicators

EDRI	**Category**	**Liability or Asset**
Hazard -MMI with a 50 year return period	HAZ	L
Hazard -MMI with a 500 year return period	HAZ	L
Hazard - % of urbanized area with soft soil	HAZ	L
Hazard - % of urbanized area with high liquefaction susceptibility	HAZ	L
Hazard - % of buildings that are wood	ISQ	L
Hazard -Population density (people per sq km)	PD	L
Hazard - Tsunami potential indicator	PL	A
Exposure-Population	PD	L
Exposure-Per Capita GDP	CA	A
Exposure-Number of Housing Units	ISQ	L
Exposure-Urbanized land Area	ISQ	L
Vulnerability -Seismic code indicator	PL	A
Vulnerability -City wealth indicator	CA	A
Vulnerability -City age indicator	ISQ	A
Vulnerability -% of population aged 0-4 and 65+	PD	
Emergency Response-Avg growth in GDP over 10 years	CA	A
Emergency Response-housing vacancy rate	PD/ISQ	L
Emergency Response-hospitals per 100,000 residents	SS	A
Emergency Response-physicians per 100,000 residents	SS	A

HDRI		
Exposure-average daily number of tourists	PD	L
Exposure-median home value	CA	A
Exposure-income generated from agriculture	CA	A
Exposure-number of business units	CA/ISQ	L
Exposure-value of power lines	ISQ	A
Vulnerability-%pop aged 16–64 that has a mobility limitation	PD	L
Vulnerability-Public education indicator(awareness about hurricanes)	SC	A
Vulnerability- Avg BCEGS grade	PL	A
Vulnerability- % of homes that are mobile	ISQ	L
Vulnerability- businesses with less than 20 employees	PD/ISQ	L
Vulnerability- % of county land detached from mainland	CA	L
Emergency Response-number of shelters available	SS	A
Emergency Response-number of hospital beds per 100,000	SS	A
Emergency Response-City layout (roads in grid -0, otherwise -1)	ISQ	A

Quantifying social Vulnerability - Dwyer et al.

House Insurance	EA	A
Income	CA	A
Tenure Type	CA	
Age	PD	
Debt	EA	L
Employment	PD/SC	A
Car Ownership	CA	A
English Skills	PD/SC	A
Household Type	PD/CA	A
Health Insurance	EA	A
Residence Type	CA	A
Disability	PD	L
Gender	PD	A

Indicators of Disaster Management - Cardona

Exposure-Population growth rate-average annual rate	PD	L
Exposure-Urban growth- avg annual rate %	ISQ	L
Exposure-people per 5km sq	PD	L
Exposure-Poverty people living below poverty level	PD	L
Exposure-Capital Stock in millions of $ per sq km	EA	A
Exposure-Imports and Exports of Goods and Service as % of GDP	CA/EA	A
Exposure-Gross domestic fixed investment	CA	A
Socioeconomic-dependents as % of working age population	PD	L
Socioeconomic-unemployment rate	PD	
Socioeconomic-debt service burden	EA	L
Socioeconomic-soil degradation	CA	L
Resilience-Infrastructure and Housing Insurance as % of GDP	CA/EA	A
Risk Identification-systematic inventory of disaster losses	PL	A
Risk Identification-hazard monitoring and forecasting	PL	A
Risk Identification-vulnerability and risk assessment	PL	A
Risk Identification-public information and community participation	SC	A
Risk Identification-risk management training and education	PL	A
Disaster Management-Organization of EM operations	PL	A
Disaster Management-emergency response planning and implementation of warning system	PL	A
Disaster Management-supply of tools, equipment, and infrastructure	CA/ISQ	A
Disaster Management-Simulation-test and updating of response capability	PL	A
Disaster Management -community preparedness and training	SC	A
Disaster Management -rehabilitation and reconstruction planning	PL	A
Government/Financial - multisector coordination	SC/SS	A
Government/Financial - existence of social safety nets	SC/CA	A
Government/Financial -budget allocation and mobilization	CA/PL	A
Government/Financial - Insurance Coverage and loss transfer strategies for public assets	EA/CA	A
Government/Financial - housing and private sector insurance and reinsurance coverage	EA	A

SoVI - Cutter, Boruff and Shirley

Per Capita Income	CA	A
Median Age	PD	A
# of commercial establishments/mile sq	ISQ	
single-sector economic --> % employed in extractive industries	PD	L
Housing stock and tenancy--> % of homes that are mobile	ISQ	L
% african American	PD	L
% Hispanic	PD	L
% native American	PD	L
% asian	PD	L
% employed in service occupations	PD	D
% employed in transportation communication and public utilities	PD	D

Munich Re - Index for Mega Cities

Hazard-Change in vibration intensity	HAZ	L
Hazard-Liquefaction (softening of subsoil)	HAZ	L
Hazard-Tsunami	HAZ	L
Hazard-Fire Following earthquake	HAZ	L
Vulnerability -Preparedness (very good,good, average, below avg)	PL	A
Vulnerability-Quality of Construction (very good, good, avg, below avg)	ISQ	A
Vulnerability- Building Density	ISQ	L
Vulnerability- Population Density	PD	L
Exposure-Average value of household for residential buildings	CA	A
Exposure-GDP for commercial/industrial buildings	CA	A

Environmental Vulnerability Index-SOPAC

Number of earthquakes over last 50 years/10,0000 sq km >6.0 Richter	HAZ	L
Number of tsunamis with run up 2m over last 50 years /10,000 sq km coast area	HAZ	L
Number of nuclear facilities	ISQ	L
Number of shipping ports	ISQ	L
Average number of tourists	PD	L

Disaster preparedness Measures – Simpson

Fire Protection

response time	SS	
# of fire stations per 1000	SS	A
Number of personnel per 1000 pop	SS	A
funding per 1000 pop	SS/PL	A
vehicles per 1000 pop	SS	A

EMS

Response time	SS	
# of available hospital/clinic beds per 1000	SS	A
# of medical personnel per 1000	SS	A

Police		
avg response time	SS	
# of personnel per 1000 pop	SS	A
funding per person	SS/PL	A
Planning and Zoning (Yes/No)		
Pre-existing emergency ordinances	PL	A
Existing Special Area Zoning	PL	A
Hazard maps	PL	A
local funding for mitigation/planning	PL	A
pre-existing recovery plan	PL	A
Emergency Management Office		
existence of Emergency EMO yes/no	PL/SS	A
staffing of EMO per 1000	PL/SS	A
existence of emergency plan yes/no	PL	A
EOC activation plan	PL	A
Age of EOC plan	PL	L
training or simulation using plan yes/no	SC	A
funding per capita	PL	A
Other Emergency Functions		
est. emergency ops center yes/no	PLN/SS	A
availability mass care sites yes/no	SS	A
drills and exercises yes/no	SC	A
existence of level of activity (LEPC) yes/no	SS	A
Additional Community Measures		
existence of community based org. yes/no	SS	A
disaster response designated yes/no	SS	A
general social service yes/no	SS	A
National Org Yes/No	SS	A
volunteer org (yes/no)	SS	A
daily newspapers yes/no	SC	A
local radio stations #	SC	A
Hazard Exposure		
earthquake MM scale mult -10	HAZ	L
chemical facilities	HAZ	L
railway facilities	HAZ	L
nuclear plant	HAZ	L
evacuation and warnings		
existence of evacuation plan	PL	A
warning system	PL	A

Community Resilience		
Total city budget per person	CA	A
cash reserves in general fund	CA	A
cash reserves as % of annual budget	CA	A
% of budget to debt service	CA	L
city's bond rating	CA	A
Social Flood Vulnerability Index -Tapsell et al		
Unemployment	PD	
overcrowding - households with more than one person per room	PD	L
long term sick	PD	L
single parents	PD	L
elderly over 75+	PD	L
Preexisting health problems	PD	L

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