



# Hazards Vulnerability & Resilience Institute

UNIVERSITY OF SOUTH CAROLINA

## Evaluation of Existing Community Disaster Resilience Approaches and Tools to Support Resilience Planning Efforts

### Summary:

- Vulnerability and resilience metrics are not the same as they measure different concepts.
- Top-down resilience metrics are best used for an initial filter or broad assessment of where more information on resilience and its drivers should be gathered.
- Bottom-up metrics can be employed most effectively after a top-down assessment narrows down study areas of interest.
- Bottom-up metrics can delve into specific communities to best target resilience programming and funding based on actionable information.

By Margot Habets and Susan L. Cutter

Report for the South Carolina Office of Resilience  
May 19, 2023



## **Introduction**

The term resilience has been around for centuries with multiple, intertwined meanings stretching from the mechanical and natural sciences to engineering, medicine, and to the humanities and social sciences (Alexander 2013). Resilience has been used for decades as an approach to examining the ability of a system or an entity such as a building to withstand a shock, cope with or absorb changes, and adapt to such changes to bounce back and regain prior functions. In the context of disaster risk reduction, resilience was initially applied to ecosystems (Holling 1973) and performance-based engineered structures including lifelines (Bruneau et al. 2003). Resilience was not really introduced into hazards or disaster planning until the mid-1990s as an approach for describing the capacity of communities to resist or recover from a disaster shock (Emrich and Tobin 2018). In this context, resilience was used to describe the multi-dimensional scale, time, and place-dependent interactions between preparedness, recovery, and adaptation in response to shocks to communities. Rather than focusing on reducing the vulnerability in places, the focus shifted to positive actions that communities could take to not only improve their capacities to withstand the impacts of disaster risks but also to bounce forward in its aftermath, not simply returning to what was there before.

In 2012, the National Academies published their seminal report, *Disaster Resilience: A National Imperative*, to address the obstacles related to increasing the nation's resilience, describe the state of knowledge about hazards resilience including baselines and performance metrics, and provide guidance on needed approaches to elevate resilience as a common goal. The study began by defining resilience as “the ability to prepare and plan for, absorb, recovery from, or more successfully adapt to actual or potential adverse events” (NRC 2012: 16). In the intervening decade, the application of disaster resilience to raise awareness about disaster risk reduction, stimulate communities to engage in and promote resilience actions has produced significant advancements in resilience planning in all sectors (Walton et al. 2021). Many communities and states now have a Chief Resilience Officer or a resilience office, resilience is incorporated into risk mitigation planning at all levels, and in South Carolina, resilience is now a required element in comprehensive plans (S.C. Code § 6-29-510).

While there is enormous enthusiasm for the idea and concept of disaster resilience, resilience measurement science and practice still are not mature enough to determine which approach works best in theory, or more importantly in practice (NASEM 2019). The purpose of this white paper is to provide a critical evaluation of the current metrics and approaches used in disaster/ hazard resilience including a comparison of their relative weaknesses and strengths to help inform South Carolina's strategic statewide resilience and risk reduction planning effort.

## **Metrics for Disaster Resilience**

There is no dominant framework or standard for resilience measurement (Cutter 2016a) because communities are different in their physical, social, and built environment characteristics, disaster risk exposures, and capacities. By measurement, we mean the action of assessing a place (or event) using a standard approach to compare the place over time, after changes in conditions, or with other places (NASEM 2019). There are a multitude of activities and frameworks for

measuring resilience, which generally focus on the inherent resilience of a community – the pre-existing resilience a community has at a particular point in time (Asadzadeh et al. 2017). Each approach requires choices on resilience definitions, input data (quantitative, qualitative), study area, and the hazards considered (Parker 2020). Individually and collectively such choices influence the complexity of the metric and its lack of transference of the approach from one place to another, or from one-time timeframe to another.

### What are resilient communities?

Resilience can be a measurable outcome, a process, or some combination of the two. Common elements in resilience frameworks focus on assets (the restoration of the physical infrastructure) to achieve an outcome after an event (static conditions), or on social processes that improve social and institutional capacities through social learning (dynamic processes). In some instances, both asset and capacity approaches are used to define community resilience. However, inherent in that conversation are the questions of resilience to what? And resilience for whom? (Cutter 2016b; Meerow and Newell 2019). These basic conceptual differences (assets vs. capacities; to what vs. for whom; and static vs. dynamic processes) influence the various measurement approaches and resulting outputs.

South Carolina defines resilience in its introduction to the draft Strategic Statewide Resilience and Risk Reduction Plan as “the ability of communities, economies, and ecosystems within South Carolina to anticipate, absorb, recover and thrive when presented with environmental change and natural hazards” (SCOR 2023, 14). In this respect, the state has taken a combination of the assets and capacities perspective in its definition.

Most measurement schemas take a broad holistic view suggesting that communities contain many different dimensions of resilience that are interdependent and connected. These inherent dimensions are often referred to as capitals (environmental, economic/financial, cultural, social, and infrastructure), and the capitals approach provides the general conceptual model for many of the measurement approaches (Tierney 2019). Other schemas focus on the disaster cycle (e.g., recovery, preparedness) and concentrate on how social and cultural systems recover post-event (Clarke and Mayer 2017) or measure resilience as the length of time for infrastructure (or lifeline) restoration (in hours or days) after a major earthquake (Poland 2009). Other approaches may be more localized in context such as the resilience of cities (Bozza et al. 2017; McPhearson et al. 2015) or rural areas (Cox and Hamlen 2015) or focused on a particular hazard or acute stressor such as flooding (van de Lindt et al. 2020). Even resilience metrics that approach the concept from the same framework can make different decisions in the variable selection and methodology, resulting in different resilience measures and findings (Jones 2018).

## How is it measured?

Common elements in community resilience measurement schemas include information on the physical attributes and assets of an area combined with social and institutional capacities. Such measurements are normally static snapshots of a particular time or context to be compared to other indicators such as sustainable development goals (SDGs), vulnerability indices, environmental justice metrics like EJ-40, or identified response needs within a community (e.g., FEMA lifelines). *Resilience metrics do not measure sustainability, FEMA lifeline performance, vulnerability, or environmental justice* (See Box 1). Resilience assessments determine prevailing conditions or baselines of existing resilience in communities. These baselines provide the foundation for future assessments (generally employing the same methodology) that can be compared to monitor progress over time. However, limitations in input data render many of the current tools or techniques not directly actionable or changeable. For example, variables that are difficult to measure, operate over longer time scales before a change occurs, or are outliers are often ignored. Instead, assessments use more available indicators as proxies arguing they still may have some importance in community resilience (Cardoni et al. 2021; Carvalhaes et al. 2022).

### **Box 1: Vulnerability and Resilience**

Social vulnerability is a product of social and place inequalities resulting in differential harm and ability to respond to different population groups (Cutter 2003). It is generally a measure of exposure to and degree of harm that a community may face. Community resilience, on the other hand, encompasses the everyday qualities of a community that may enhance its ability to prepare for, respond to, and recover from hazard events (Cutter et al. 2014). Their relationship can be conceptualized as a Venn diagram, with a level of overlap between the two, but still distinct differences.

Some indices that purport to measure resilience only use vulnerability indicators, such as the U.S. Census Bureau's (USCB) Community Resilience Estimates (CRE), assuming that the two are opposites (USCB 2022). However, this would mean that all places with high social vulnerability have low community resilience, which has been refuted (Derakhshan et al. 2022). Therefore, if you are measuring resilience, you are not necessarily measuring vulnerability and it is important to approach the two separately. This is the methodology adopted by the National Risk Index (NRI) and allows for the clear distinction between the two concepts while also understanding how they overlap (Zuzak et al. 2023).

There are four primary ways that researchers implement resilience measurements: 1) checklists, 2) scorecards, 3) indices that create a resilience assessment tool, and 4) mathematical/statistical models. Scorecards and checklists tend to take a qualitative or self-reported approach. They identify focal points of resilience in planning, and local business, and ask local areas to determine their presence or absence within the community (a checklist) (Sempier et al. 2010) or provide some assessment of the attribute's conditions using a scorecard (Berke et al. 2019; Malecha et al. 2021).

The most common way to measure resilience is by using multi-variate composite indices (Cutter 2016a). Resilience indices choose a variety of quantitative variables that theoretically enhance resilience and combine them to create a comparative value of resilience for a selected study area. These methods tend to be larger data aggregations and normally do not elicit participation from local stakeholders in their construction (Asadzadeh et al. 2017).

Lastly, mathematical models and more advanced models such as AI try to model the performance of infrastructure, human decision-making, and complex systems to understand the dynamic forms and processes of resilience (Yabe et al. 2022). The results or outputs of resilience measurement often are visualized through different types of mapping, charts, and dashboards which communicate multiple visualizations and offer a more holistic view of community resilience (Nguyen and Akerkar 2020).

Within each type of metric, researchers have to make decisions on how resilience is defined and how it will be measured, either subjectively (defined by the subject) or objectively (defined by theory and literature) (Jones 2018). Comparative reviews of the relative strengths and weaknesses of various resilience metrics and tools abound with critiques ranging from conceptualization, to methods, to input data (Bakkensen et al. 2017; Cai et al. 2018; Koliou et al. 2018; Johnson et al. 2020; NASEM 2019; Nguyen and Akerkar 2020; Sharifi 2016). However, these critiques also highlight room for improvement, especially in translating the science of resilience metrics to practice. Aligning top-down metrics comparable across multiple areas with more locally-based bottom-up ones that may not be comparable in other places has been the major impediment in moving community disaster resilience concepts to action (Cutter 2018).

#### What scale and units of measurement are used?

The choice of scale often depends on the level of decision-making addressing resilience as well as the availability of data for analysis. In more qualitative schemas, scale also depends on the type of tool used. An institution that may address resilience at a national level, like FEMA may only be interested in resilience at a state or county level, while a state or county may be able to fund specific projects and would find a zip code or census tract-level analysis more helpful. The scale of data that is available can be a large limitation for resilience measurement. Since individual-level data is unavailable, aggregated demographic data are used but this must be done with caution to avoid issues with interpretation (Chu et al. 2021).

The unit of analysis is another consideration. Units of analysis are the objects of the study—communities, watersheds, states, and countries. For communities, the unit of analysis is defined as the administrative boundary and is further defined as counties, municipal boundaries, census tracts/blocks, zip codes, or metropolitan statistical areas. Many of the data inputs on the resilience capitals come from Census information, so census tracts/blocks, zip codes, or other census-designated geographies define community boundaries instead of actual jurisdictional control. For some localized applications census-defined enumeration units are problematic where other defined areas (e.g., watersheds, flood zones, neighborhoods, land use) might have more currency for measuring community resilience.

## **Fit for Purpose: Top-Down versus Bottom-Up Tools**

While existing tools are useful for their specific design purpose, they are often limited in their application to the specific and localized needs and investments of communities. In addition, many resilience metrics are only conceptual or have been developed for one area and have yet to be widely implemented. Resilience metrics can be described as top-down or bottom-up. While theoretically and conceptually driven and often using national datasets for consistency, top-down measurements use a single value to represent all the dimensions of resilience. Top-down schemas are more policy-oriented at national, regional, and state scales where counties are the unit of analysis. The top-down schema provides comparative analyses across large geographic areas based on aggregated data.

In contrast, bottom-up approaches, provide a rich narrative on community change and actions at very localized scales (sub-county). The use of qualitative data or experiential information is not generalizable across broader geographies. There is a need to consider “fit for purpose” in the selection of tools based on policy or local action orientation. In either case, there is a need to reflect local conditions based on actionable data yet are able to scale up beyond the local community (bottom-up) to reveal a broader pattern of resilience at larger scales, or downscaled disaggregated national or state data to reflect local variability to partially capture local assets and capacities.

A summary of commonly used and/or cited resilience indices is provided in Table 1. The methodology used in the metric as well as the conceptual structuring of resilience (capitals) are provided. Additional information including the approach, goal, positives, critiques, and a sample of included variables for each metric is included in Appendix A. General findings for top-down and bottom-up metrics as well as room for improvement are discussed below.

TABLE 1 – Summary of Indicators/Tools Described split by Top-Down or Bottom-Up approach

Indicator Name	Author(s)	Scale of Analysis	Model/ Tool	Indicator	Scorecard /Checklist	Dimensions/Capacities Identified
<b>TOP-DOWN</b>						
Baseline Resilience Indicators for Communities (HVRI BRIC)	Cutter et al. 2014 Derakhshan et al. 2022	County, Tract		X		Social, economic, community capital, institutional, housing/infrastructure, environmental
FEMA Community Resilience Index (FEMA CRI)	FEMA 2022	County, Census Tract		X		Population, Household, Housing, Healthcare, Economic, Connection to Community
Community Intrinsic Resilience Index (CIRI)	Gerges et al. 2022	County		X		Transportation, energy, health and socio-economic
Community Resilience Index	Sherrieb et al. 2010	County		X		Social capital, Economic development
Natural Hazard Resilience Screening Index (NaHRSI)	Summers et al. 2018	County		X		Natural environment, built environment, society, governance, and risk
PEOPLES Framework	Renschler et al. 2010 Cimarello et al. 2016	Community	X			Population and demographics, environmental and ecosystem, organized governmental services, physical infrastructures, lifestyle and community competence, economic development, social-cultural capital
<b>BOTTOM-UP</b>						
Coastal Communities Resilience Index (CCRI)	Sempier et al. 2021	Community			X	Critical infrastructure, transportation, community plans, mitigation measures, business plans, social systems
Communities Advancing Resilience Toolkit (CART)	Pfefferbaum et al. 2013; 2015	Community	X			Connection and caring, resources, transformative potential, disaster management, information and communication
Composite of Post-Event Well-being (COPEWELL) Model and Rubric	Links et al. 2018; Schoch-Spana et al. 2019	County; Community		X	X	Index: Pre-event community functioning; Prevention and Mitigation; Population vulnerability, inequality, and deprivation; Social capital and cohesion; event preparedness and response; external resources
Los Angeles County Community Disaster Resilience Project (LACCDR)	Eisenman et al. 2014	Community	X			Education, engagement, self-sufficiency, partnership
Rural Coastal Community Resilience (RCCR) framework	Jurjonas & Seekamp 2017; Jurjonas et al. 2020	Community			X	Livelihood dependency/diversity, poverty/prosperity, un/sustainable development, community disengagement/cohesion, rigidity/agency
Rural Resilience Index (RRI)	Cox and Hamlen 2015	Community		X		Social fabric, community resources, disaster management

## Top-Down Resilience Metrics

Top-down resilience metrics are used to give a snapshot of the inherent resilience of a study region. They can be used for a comparative understanding of the resilience landscape of a study region that can lead to improved decision-making at a state or county scale. This scalability lets stakeholders understand resilience across a large area while targeting specific counties that may need additional resilience resources. Since county-level analysis aligns with existing resilience programming from the federal government, top-down indices are a good first step to using those resources in the places they are most needed.

All of the top-down approaches begin their study with a pre-determined definition and framework of resilience. According to their theoretical approaches, FEMA CRI, the PEOPLES framework, and NaSHRI conflate resilience with social vulnerability, whereas BRIC, CIRI, and the Community Resilience Index either explicitly define their approach to the relationship between resilience and vulnerability, or only include variables that are generally not used in social vulnerability measurement. For example, the Community Resilience Index only addresses social capital and economic development, and CIRI only uses 15 variables whereas BRIC widens the scope of resilience to include 49 variables within social, economic, environmental, community, institutional, and infrastructural capitals.

All top-down resilience metrics discussed here are indices created from local or national datasets except for the PEOPLES Framework which is a largely GIS-based tool. Large, publicly available datasets, while often only available at the county or census tract scale, are consistently available over time and can be used to identify broad drivers and temporal patterns of resilience. Locally sourced datasets, as used in CIRI, can be more accurate and more data related to resilience may be available. Depending on the scale and datasets used, top-down resilience metrics can be quickly calculated, but some metrics rely on calculated datasets that become more time and labor-intensive such as NaHRSI and the PEOPLES Framework which require complex modeling and extensive data collection at 117 and 95 variables respectively. CIRI includes an additional equation that would model resilience after a hazard, but this can only be related to infrastructural resilience (Gerges et al. 2022). In addition to choosing variables that represent resilience, some indices strive to include actionable variables, those that can be directly impacted by governments, to help identify what changes need to be implemented to improve resilience for the target community. Of all the indices (and variables within them) listed in Table 1, none are completely actionable, but all have some and widely differing actionable variables.

An additional difficulty of top-down resilience indices is their wider application and validation of outcomes. Variables in existing resilience indices may not always be applicable to each study area or data may not be available at chosen locations or scales. Resilience is also a place-based process and variables that may do a good job quantifying inherent resilience in one area, for example on the coast of South Carolina, may be a poor choice for a variable in a mountainous land-locked state such as Colorado. Expert and stakeholder input can improve variable selection to possibly move national resilience indicators to the state and local scale, making them more operational. Quantitative metrics like indices also require statistical and external validation to make sure the measurement accurately portrays what it says it will.



Validation varies over the metrics presented, but there is work to be done overall in resilience metric testing (Koliou et al.2018).

### Bottom-Up Resilience Metrics

Though bottom-up resilience metrics may not always use a resilience framework created by the study community, they are implemented at a local scale and are measurements of local, place-based community resilience. Place-based means that the indicators used as well as the people surveyed are local and account for contexts of resilience that may not be found elsewhere. These can be found in top-down resilience metrics if created in partnership with communities, but bottom-up metrics have this built into their methods from the beginning. The only index in our assessment that is truly bottom-up is the RRI, which identifies variables through stakeholder engagement and builds an index from these variables only (Cox and Hamlen 2015). In addition, since bottom-up metrics involve the community in conceptualizing and measuring resilience, they can also act as a resilience-building exercise.

Most bottom-up metrics are either community scorecards and checklists or community assessments. Checklists, such as CCRI identify a specific audience for the assessment and direct them to grade different parts of the study area on resilience qualities that generally cannot be quantitatively measured. These types of assessments are easier to implement than larger focus groups or participatory action research, but still function as both a teaching and assessment mechanism. Generally, scorecards are created through an assessment of resilience literature to identify what qualities improve the resilience of the community targeted and then administered to that community. The production of the actual assessment can be created alongside stakeholders as it is done in COPEWELL, or it can be research-based and adapted once administered similarly to how the RCCR Framework approached its scorecard.

Community assessments take many different forms. The two assessments discussed here are chosen to show the different approaches one can take in qualitatively assessing community resilience in this way. CART adopts a four-stage participatory methodology, which, while time-consuming, involves the target community through every step of the resilience assessment process and results in a plan for resilience improvement. LACCDR takes a public health approach to resilience and trains groups on resilience building for them to then take home and implement which involves a high reliance on established NGOs, improving their resilience but possibly taking away from other programming priorities. Both community assessments involve the creation of a resilience toolkit and implementation over multiple meetings and stages with ample opportunity for stakeholder feedback and revision. They are time-intensive, involving multiple different qualitative methods (i.e., interviews, surveys, focus groups, community mapping, network analysis) to determine very localized but detail-rich understandings of community resilience.

Bottom-up methods vary in approach and methodology to address resilience in a multitude of ways, but their scope normally narrows to one or two capitals of resilience to make them doable. The audience of these metrics can vary from government workers to NGOs to the public. Finding participants and drawing out actions that can improve resilience takes time and effort, not only on the researcher's behalf but also by the community that is being assessed. These limitations can

make it difficult to repeat bottom-up methodologies or apply them across different parts of a larger study area.

## **Conclusions**

There is no single resilience metric that can tell researchers and stakeholders everything they need to know about a study area's resilience. However, resilience metrics are not all created using the same approach, and they must be critically assessed before being applied to a study area (Jones 2018). Resilience is theoretically different than vulnerability, however, many resilience metrics conflate the two concepts, resulting in a measurement that is not explicitly resilience.

Top-down resilience indices involve large datasets that distill resilience down to quantitative variables that are either combined into an index or used in GIS programs that attempt to portray the systems of systems of resilience. These metrics can be used to aid in decision-making and track resilience over time but are not always actionable and require local input to accurately integrate more local measures of resilience. Also, there is still work to do to test and validate different resilience metrics (Koliou et al. 2018, Parker 2020).

Bottom-up metrics are generally limited to approaching resilience through one or two capitals due to their time- and resource-intensive nature. The interactive nature of bottom-up metrics may result in the metric acting as a resilience intervention itself and can result in specific resilience actions that are community-identified and supported. However, the time intensity of these metrics means that it is difficult to track resilience over time or to administer multiple bottom-up metrics over a larger area without substantial dedicated resources. As it stands, a combination of top-down and bottom-up approaches is necessary to both identify areas with low inherent resilience (policy-oriented) and actions that will be community-supported and effectively improve resilience.

Currently, Charleston, Lexington, Florence, and York Counties all have specific resilience chapters as parts of their comprehensive plans. They all identify hazards that directly impact the counties and key tasks or actions that must be taken to improve their resiliency to these events, but there is no evidentiary basis (e.g., direct or indirect measurement of resilience) for such actions or mechanisms for monitoring their effectiveness. A top-down resilience metric coupled with bottom-up resilience priorities can effectively target communities at the state and county level that are less resilient and guide programs and projects that local communities self-determine. This is necessary to efficiently and effectively utilize limited resilience funding for the largest impact on local community resilience.

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## Appendix A: Summary of Metric Approaches and Critique

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### BRIC

49 Variables; hierarchical construction with internal validation

Goal: To provide a reference point for examining current inherent resilience and aid in decision-making with some actionable variables

Plus: theoretically and conceptually driven; ease of use/transparency; use of national datasets for consistency; monitor drivers and changes over time; address inequality through visualization

Minus: single value not representative of all dimensions; not ground-truthed or validated; does not measure interdependencies; internal consistency too variable; not all variables actionable; county scale (and unit of analysis) too coarse; comparative descriptive NOT absolute predictive so dependent on study area selection

Variable Examples: medical facilities (beds, physicians, psychosocial support facilities per 1,000 people); Business size; Gini coefficient; impervious surface change; mitigation cost share percentage; Social assistance services per 1,000 people

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### Coastal Community Resilience Index

Checklist format with two hazard scenarios built in.

Goal: Targeted to local planners, engineers, managers, or administrators for a guided self-examination of community resilience that can also be converted into an index for comparison.

Plus: structured self-assessment; easy to apply elsewhere; easy to understand; translates into a resilience index; relatively quick to implement

Minus: not a replacement for detailed study; requires expert knowledge on wide-ranging topics; relies on hazard event scenarios; subjective language for rating “strong” social systems

Variable examples: location of critical facilities; evacuation route availability; comprehensive plan contents; early warning system; mitigation measures and activities

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### CART

Four stage participatory action methodology focused on resilience perception

Goal: Provide a toolkit focused on group participation to define a community profile of resilience and plan for improved resilience

Plus: evidence-informed and supported theoretically; field-tested; participation is a resilience intervention itself; involves stakeholders in creating knowledge and solutions; intervention and implementation driven

Minus: time and labor intensive; application of assessment to new study areas difficult resulting in limited application; will not result in measurement of resilience, rather interventions



Variable examples: neighborhood infrastructure mapping; community conversations; community ecological maps; stakeholder analysis; SWOT analysis; capacity and vulnerability assessment

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## **CIRI**

15 Variables; Hierarchical construction, with variable compared to “ideal” and weighting determined by user

Goal: To provide an inherent resilience index and post-disaster resilience that uses an “ideal” goal for each variable and with weighting that is customizable to each place where it is implemented.

Plus: Highlights infrastructural resilience; includes novel penalty system that could model limiting agents of recovery; compares score to a theoretical “perfect score”

Minus: Limited list of indicators; weighting and penalty schemas difficult to implement; definitions of variables unjustified; requires proprietary data; justification of “perfect score” arbitrary; penalty system requires more testing; index not ground-truthed; not all variables actionable

Variable examples: road area, transit performance, microgrids, hospital beds, education, creative class

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## **Community Resilience Index**

17 Variables; hierarchical construction with internal and external validation

Goal: Measure adaptive capacity through social capital and economic development specifically

Plus: ease of use/transparency; easily visualized; monitor changes over time

Minus: limited variables; single value not representative of all dimensions of community resilience; not all variables actionable; county scale (and unit of analysis) too coarse; comparative descriptive NOT absolute predictive so dependent on study area selection; not all variables replicable

Variable examples: Gini coefficient; net gain/loss rate in business year; occupational diversity; two-parent families; net migration rate

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## **COPEWELL**

49 Variables; System dynamics model for index; Rubric-based self-assessment

Goal: Assessment of pre-event, event, and post-event resilience characteristics through system dynamics index development and additional community assessment

Plus: Index and self-assessment based on same theoretical framework; assessment co-developed with community-level users; assessment is implementation-driven; participatory assessment acts as resilience intervention itself; index relies on national datasets; index is hazard-specific

Minus: Time-intensive; index and assessment not well connected to create holistic view of resilience; scale of index very coarse (County); application of assessment to new study areas difficult resulting in limited application; Index includes hazard exposure and vulnerability, conflating ideas of risk and resilience; not all index variables actionable

Variable examples: homes with internet service; food and water providers; insurance factors for women, Medicare enrollees, and all adults; housing stock; income inequality; affiliation with religious groups; hazard impact

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### **FEMA Community Resilience Index**

22 Variables; Additive across all variables

Goal: Through accepted variables from the literature, create a universal resilience index

Plus: constructed from variables found across various resilience methodologies; available for download online from FEMA; incorporated into FEMA Resilience Analysis and Planning Tool (RAPT)

Minus: Overlap between vulnerability and resilience not well justified (uses social vulnerability indices in variable selection); uses all publicly available data;

Variable Examples: population without high school diploma; owner-occupied housing; number of hospitals; population below poverty level; income inequality; population change

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### **LACCDR**

Training that includes network analysis, household survey, table-top exercise, and process evaluation/reflection

Goal: Operationalize and measure factors and strategies to increase community resilience through community coalition training

Plus: Training initiative; directly actionable; toolkit developed through stakeholder engagement; interactive method directly improves resilience as its own action; resilience improvement through established groups; public health led program (can be both plus and minus)

Minus: Time and resource-intensive; requires involved community organizations for implementation; missing factors of resilience other than social/community

Variable examples: Pre-/Post- incident wellness; preparedness education; self-sufficiency; partnerships between/within government and NGOs

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### **NaHRSI**

117 Variables; Hierarchical construction with no internal validation

Goal: Index of basic resilience that incorporates hazard risk within the index rather than creating a separate exposure index for comparison

Plus: theoretically/conceptually driven; extensive measurement variables; can integrate hazard event for post-event resilience and recovery modeling

Minus: Includes hazard exposure and vulnerability, conflating ideas of risk and resilience; intense data management required; complicated model/equations for index construction; not validated or ground-truthed; datasets inconsistent

Variable examples: communication continuity; biodiversity; land area type; hazard exposure and loss; access to social support; structure vulnerability; condition of natural environment; labor-trade services

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### **PEOPLES Framework**

95 Variables; GIS overlay methodology; systems of systems approach

Goal: Create a GIS tool to investigate different interactions across variables

Plus: holistic view of community resilience; geospatial focus;

Minus: requires complex modeling and extensive data collection; conflates vulnerability and resilience within population demographics dimension;

Variable examples: population demographics (age, gender, race,); water, air, soil quality; executive and administrative emergency functions, cultural facilities, lifelines (internet connections, postal, healthcare, food supply, utilities, and transportation); collective action and efficacy (conflict resolution and quality of life); financial services, CPI; employment and business services; social services

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### **RCCR Framework**

Risk and Resilience spectrums created through local perception; Later revised to include climate justice

Goal: Understand locally perceived resilience needs in coastal rural communities

Plus: Themes designed with practical application in mind; themes assessed by community members through interviews and focus groups; focused on engaging communities in resilience conversation; stimulate capacity building dialogue; manageable tool for replication; avenue for community members to describe place-based issues and perceptions

Minus: Frames resilience and vulnerability as opposing forces influencing adaptive capacity; only pre- and post- surveys from focus groups; not generalizable to other scales; findings very localized; small group of people engaged at one time

Variable Examples (Survey): Threat of sea level rise, saltwater intrusion, and flooding; vulnerability of the same three hazards; level of preparedness to the same three hazards

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## **RRI**

Blend of qualitative and quantitative data through Citizen engagement in generating locally relevant data through Likert-scale

Goal: While an index, this is a bottom-up tool due to the identification of the variables included occurring at the community level, creating a place-specific index

Plus: Indicators theoretically bound and iteratively chosen through local knowledge; focus on the implementation of plan to increase resilience; developed in tandem with hazard risk assessment tool

Minus: Due to local input, variables may not be widely applicable; measurement of resilience through survey method - difficult to measure over time; time and resource intensive; final product not easily interpreted; methods and variable list incomplete

Variable examples: Community wellbeing; housing and public spaces; communication options; hazard awareness; emergency operations; community engagement