UNITED NATIONS DEVELOPMENT PROGRAMME

DISASTER RESILIENCE MEASUREMENTS

STOCKTAKING OF ONGOING EFFORTS IN DEVELOPING SYSTEMS FOR MEASURING RESILIENCE

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A. OVERVIEW

Purpose

In recent years, efforts have been undertaken by various organizations to design indicators for measuring resilience more broadly. This review, commissioned by UNDP, **takes stock** and **provides an overview** of ongoing efforts at developing and applying **measurement frameworks for disaster resilience**. In addition, it attempts to identify **lessons** from measurement systems that have already been in place. This will inform measurement efforts in countries where efforts are being made to provide added impetus to building disaster resilience.

Disaster Resilience

'Resilience' was selected *the* global development **buzzword** of 2012 by an aid industry website.[1] There is currently an '**explosion** of consultations and initiatives on resilience, happening at global, regional and national levels, with a multitude of interpretations on what resilience is, that is largely uncoordinated' (*Mitchell 2013, p.1*). Despite its current influence, **no agreement** exists over the exact meaning of the concept. UNDP defines building resilience as a "*transformative process of strengthening the capacity of men, women, communities, institutions, and countries to anticipate, prevent, recover from and transform in the aftermath of shocks, stresses and change."* (*UNDP, no date*).

This review is concerned with measurements of resilience against **natural disasters**. It includes measurements that focus – partially or fully – on tropical cyclones and related storm surges, droughts, earthquakes, biomass fires, floods, landslides, tsunamis and/or volcanic eruptions. The review also includes issues which are closely linked to disaster resilience such as **disaster risk management, vulnerability to disasters** and **food and nutrition**. It does not cover the more narrowly focused forms of resilience, such as psychological resilience, limitation to physical resilience from an engineering point of view, cyber resilience, and supply chain resilience.

[1] The international development buzzword of 2012, blog, Devex.com, 20/12/2012, www.devex.com/en/news/the-international-development-buzzword-of-2012/80011

Measuring Disaster Resilience

Unsurprisingly, the identification of metrics and standards for measuring resilience remains a significant challenge. **No consensus exists currently on how to measure resilience** (see e.g. *Béné 2013, Constas/Barrett 2013, Frankenberger/Nelson 2013, Gall 2013, Mitchell et. al. 2013, Mitchell 2013, Ranger/Surminski 2013).*

This overview of disaster resilience measurements will first look at **what is currently being measured** in disaster resilience and the **characteristics** of the measurements. It will then provide a mapping that summarized current specific efforts to measure disaster resilience. Finally, the overview provides some **recommendations** based on the mapping and a literature review.

B. WHAT IS BEING MEASURED?

Measuring disaster resilience is currently carried out in very different ways. The following criteria can be used to distinguish between and classify the different approaches:

1. Which **elements** of disaster resilience are included in the measurement?
2. Which **levels** of resilience (input, output, outcome, impact) does the measurement capture?
3. How many **dimensions** of disasters resilience does the measurement include?
4. What is the smallest **unit of analysis**?

1. Which elements of resilience are included?

An important step in identifying the most appropriate way to measure disaster resilience for a particular context is to look at **which elements of resilience** are included in the measure:[2]

a. measuring **well-being** before and after a disaster
b. measuring **vulnerability**
c. measuring **resilience capacities** to cope, adapt, and transform in case of a disaster
d. measuring disaster-related **shocks, losses and stress**
e. measuring the **reaction** to and recovery from disasters
f. measuring **programme results**

a. MEASURING WELL-BEING

The assumption is that the degree of resilience of a particular household, community or population can also be determined partially by assessing the extent to which they can **maintain general well-being in the event of a disaster**. These measurements typically rely on more **traditional development indicators** related to livelihoods, economic situation, human capital, nutrition, etc. These measures of well-being do not necessarily have to be related to disasters, disaster resilience, disaster risks, and so on. A number of **general development indicators** can typically be used to compare well-being over time. To be meaningful for assessing resilience, measurements are required *at least* once **prior** to and once **after** a disaster.

An example is UNDP's ***Community Based Resilience Analysis (CoBRA):*** CoBRA uses a **Household Economy Approach** (HEA) to serve as a meta-indicator; a survival threshold represents the total income required to cover the costs of food, food preparation and water, and a livelihoods protection threshold that covers expenditure for basic survival access to basic services, medium-term livelihoods and standard of living.

[2] partially adapted from Frankenberger/Nelson 2013, pp. 32-34

b. MEASURING VULNERABLITY

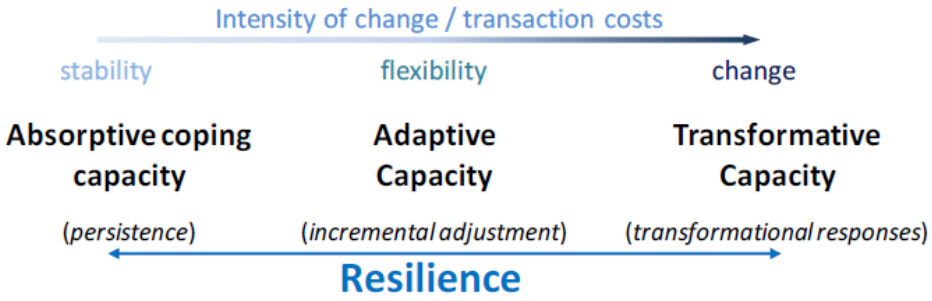
To measure vulnerability, we must determine how exposed people are to disasters (=exposure) and how likely it is that they get harmed (=susceptibility). Although related to resilience, the methodology of measuring vulnerability is more advanced (see e.g. *Béné 2012, Gall 2013*).

c. MEASURING RESILIENCE CAPACITIES

The *capacity* for resilience in case of a disaster is typically regarded to be at the core of the resilience concept as well as of resilience measurements. Resilience capacities depend – as described above – largely on subjective or empiric characteristics and a certain set of assumptions about resilience.

Since an increase in 'capacities' is by definition an **out*put*** (it is not yet a change in behaviour), measurements of capacity need to be kept on that level as well. The advantage is that these measurements are also disaster-independent, which means they can be measured at any time. This implies, however, that resilience capacities as an output do not tell us anything about the extent to which these capacities are actually used in case of a disaster (or a simulation), and – even more importantly – if they are effective.

A frequently cited delineation of different components of resilience capacity is the differentiation between ***absorptive*, *adaptive*, and *transformative* capacities** (*Béné/Wood/Newsham/Davis 2012*). These three structuring elements are an analytical and measurement framework aimed at understanding better what exactly 'strengthening resilience' means.



Source: Béné/Wood/Newsham/Davis 2012

Combining these three types of resilience capacities with the different levels of actors (individuals, households, communities, states), this leads to a measurement matrix of 4 x 3 = **12 elements of disaster resilience measurement**:

	measurement of absorptive capacity	measurement of adaptive capacities	measurement of transformative capacities
Individuals	absorptive capacity of individuals	Adaptive capacities of individuals	Transformative capacities of individuals
Households	absorptive capacity of households	Adaptive capacities of households	Transformative capacities of households
Communities	absorptive capacity of communities	Adaptive capacities of communities	Transformative capacities of communities
Systems / States	absorptive capacity of states	Adaptive capacities of states	Transformative capacities of states

Source: adapted from Mitchell 2013, p.17

Many of the existing measurements of disaster resilience entail the quantification of resilience *capacities*: The monitoring framework for the ***Hyogo Framework for Action (HFA)*** tracks goals and priority areas on the activity and output level using a set of capacity indicators based on self-assessments. The ***Post-HFA*** includes quantitative measures of disaster loss and longer time impacts, and also of preparedness (risk drivers, resilience, disaster risk, policies). The ***WorldRiskIndex*** includes high-level data on coping (=defined as capacities to reduce negative consequences) and adaptive capacities (=defined as capacities for long-term strategies for societal change). The ***Global Focus Model*** by OCHA and Maplecroft includes general measurements on exposure and vulnerability, but nearly 1/3 of weight is given to measurements of capacities for economic health, institutional resilience and infrastructure. The ***Prevalent Vulnerability Index*** by the Inter-American Development Bank uses a composite indicator consisting of eight high-level economic and social variables. The ***Baseline Resilience Indicators for Communities (BRIC)*** based on the Disaster Resilience of Place (DROP) model defines a set of indicators that measure exclusively the antecedent conditions within communities.

d. MEASURING SHOCKS, LOSSES AND STRESS DUE TO DISASTERS

Quantifying and measuring the impact of disasters is not only necessary for measuring resilience, but is a particular set of measurements by itself. It refers to measuring the *covariate* as well as the *idiosyncratic* shocks.[3]

The International Disaster Database ***EM-DAT*** (www.emdat.be), for example, provides information on the human impact of disasters. ***DesInventar*** (www.desinventar.net) is a tool for generating national disaster inventories and constructing databases that capture information on damage, loss and general effects of disasters. The ***PREVIEW Global Risk Data Platform*** (preview.grid.unep.ch/) is a multiple agencies effort to share spatial data information on global risk from natural hazards.

e. MEASURING REACTION: RESPONSE AND RECOVERY

To measure the response and recovery after a disaster, we must go beyond the assumed ex-ante *capacity* to absorb, adapt and transform; we have to try to capture the extent that individuals, households, communities, systems and countries do ***actually*** **absorb, adapt and transform** as a result of a disaster.

An example is the ***Tsunami Recovery Impact Assessment and Monitoring System (TRIAMS)***, which used a limited set of indicators to track recovery after the Indian Ocean earthquake and tsunami in 2004 in four affected countries. ***Indonesia's Disaster Recovery Index (DRI)***, for example, measures the progress of **recovery** and **resilience** in communities affected by the Mount Merapi eruption in 2010 and Lahar floods in 2011. The index utilizes 22 variables to determine how communities are recovering from the volcanic eruption in terms of restoring infrastructure, housing, livelihoods, and social structures, among other things. The index uses data collected through **surveys** of ca. 1,230 households that were affected and which have since received rehabilitation and reconstruction assistance. The household survey uses long term data to compare the situation in a community *before* a disaster to that *after* the disaster and to the situation following the *implementation* of

[3] shocks are Idiosyncratic when one household's experience is unrelated to neighbouring households'; shocks are covariate if many households in the same locality suffer similar shocks

rehabilitation and reconstruction programmes. Another example of measuring the reaction to a disaster is the ***MCEER R4 Resilience Framework***. In addition to two dimensions that track preparedness (**robustness, redundancy**), the framework measures two dimensions that track the *reaction* in case of a disaster (resourcefulness, rapidity). Another example is ***ResilUS***, a prototype simulation model of community resilience in the U.S. that focuses on recovery and loss estimation. The ***Country Resilience Rating*** proposed by the World Economic Forum includes capacity and preparedness measurements (robustness, redundancy, and resourcefulness) as well as reactions *after* a disaster (response and recovery).

f. MEASURING PROGRAMME RESULTS

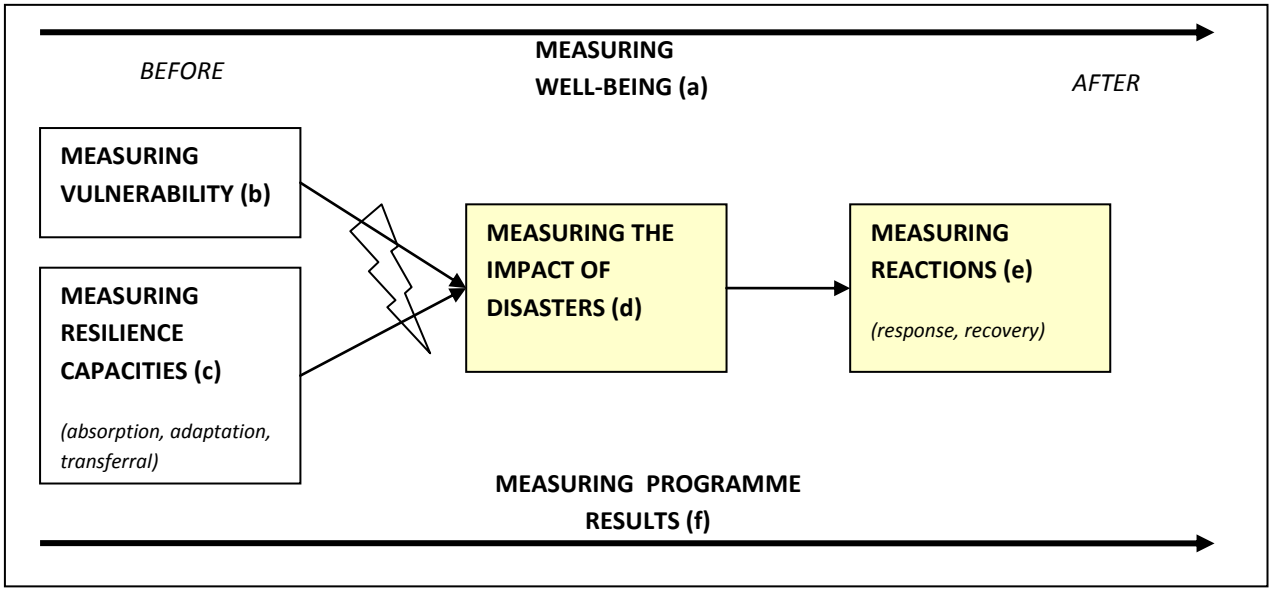
In most cases, programme results are different from more general measurements of resilience in two ways:

a) they focus on more **narrow** elements of resilience (e.g. on a specific resilience capacity or a specific sector or type of disaster)
b) they contain more details on the **activity and output level** than broader measurements, to better reflect the details of a programme intervention

CONCLUSION

Data on all dimensions of disaster resilience in a broad sense is usually required to obtain a complete picture of resilience and how it changes over time and in case of a disaster. However, one can look at measurements of resilience capacities and on reactions and recovery as resilient measurements *in a narrow sense*.

Graph 1: Elements of measuring disaster resilience



2. Which level of resilience does the measurement capture?

A somewhat different – but equally useful – analytical lens to distinguish between the various attempts to measure disaster resilience is the different **levels of the result chain**. In general, measurements of resilience capacity track inputs, activities and outputs, outcomes or impact.[4]

Inputs typically relate to government inputs, inputs from communities, sectors or firms, and inputs from households themselves. **Outputs** typically refer to reduction of exposure to disasters, exposure to vulnerabilities, resilience capacities and actions. **Outcomes** can refer to actual outcomes observed in the event of a disaster, or modelled losses based on probabilities. The **impact** refers to the degree that households, communities, systems or countries can maintain well-being in the long run despite a disaster.

LEVEL	FOCUS	ADVANTAGES AND DISADVANTAGES	EXAMPLES OF INDICATORS
Impact		Advantages: Simple to communicate Disadvantages: Risk that, rather than create right incentives, it may simply transfer too much responsibility to ex-post action	• # of people falling into poverty as a result of a disaster
Outcome *(can be observed only after a disaster or a modelling exercise)*	***Actual* resilience**	Advantages: Simple to communicate; politically motivating Disadvantages: can only be measured after a disaster; cannot track annual progress as would need averages over decades	• Mortality • Economic losses • Economic losses as a proportion of GDP • Damage to household assets • Damage to critical infrastructure • Government expenditure on disaster relief and recovery
	***Modelled* resilience**	Advantages: Can track modelled losses, to get over inter-annual variability; modelling capacity would help assess effectiveness of investments; models already used in some form in many countries Disadvantages: Potentially difficult to gain support; expensive; poor coverage of all areas/hazards	• Average annual mortality • Average annual economic loss
Output *(can be observed prior to a disaster)*	**Exposure**	Advantages: Relatively cheaper and easier to measure; can be guide to action Disadvantages: Only describes part of system; need additional quality/effectiveness factors; exposure needs modelled environment given dynamic changes (e.g. migration, climate change)	• % of assets/population exposed
	Vulnerability		• % of population with access to livelihood asset protection measures - insurance and social safety nets • % of buildings complying with hazard-resistant building codes
	Resilience Capacities		• % of population with access to risk information • % of firms adopting international risk management standards • % of development decisions that incorporate disaster resilience

[4] using the UN terminology for results (see UNDG 2011, Results-based Management Handbook, www.undg.org/docs/12316/UNDG-RBM%20Handbook-2012.pdf

Input	**Government** **Communities** **Sector/firms** **Households**	Advantages: relatively cheaper and easier to measure; good guide to action Disadvantages: Poor at assessing potential outputs and outcomes; quality/effectiveness more difficult to assess	• % of government expenditure invested in disaster resilience and disaster risk reduction

Source: adapted from Mitchell et al 2013, p.xii; Ranger/Surminski 2013, p. 17

Many measurements focus on **inputs and outputs**: The monitoring framework for the ***Hyogo Framework for Action (HFA)***, for example, measures resilience on the levels of input, activity and output. For outputs, the indicators are mostly limited to the actions taken and do not include vulnerabilities or exposure. The ***WorldRiskIndex*** combines output-level measures on exposure and vulnerability (susceptibility, coping and adaptive capacities, but not action) and some limited input-level data (public and private health expenditure)**.** The ***Global Focus Model*** by OCHA and Maplecroft includes input and output level data covering exposure, vulnerability, and capacities on economic health, institutional resilience and infrastructure. The ***Minimum Characteristics of Nepal Risk Reduction Consortium*** use – as a first step – only output indicators to measure minimum characteristics of disaster-resilient communities in Nepal.

Actual resilience outcomes are used in a number of measurements: UNDP's ***Community Based Resilience Analysis (CoBRA)*** makes use of before and after measurements of a Household Economy Approach (HEA) Response Threshold. The ***Prevalent Vulnerability Index*** by the Inter-American Development Bank uses a composite indicator consisting of eight economic and social outcome indicators. The ***Tsunami Recovery Impact Assessment and Monitoring System (TRIAMS)*** combines 27 output indicators with 24 outcome indicators.

Few resilience measurements currently **model resilience outcomes**: The proposed ***Post-HFA*** measurement framework includes coping capacities (=outputs), but is one of the few approaches that include modelling economic losses from disaster (=outcomes).

3. How many dimensions does the measurement include?

Each measurement is based on a **theoretical framework of disaster resilience**. This requires decisions about which dimensions to include in the resilience measurement. This is necessarily a somewhat subjective decision: *'It is by no means obvious what leads to resilience in a complex system, or which variables should be measured in a given study of resilience*" (Cumming 2005, p.976).

- **Narrow measurements** focus on a small selection of components. This is typically the case for measurements designed by specialized organizations or individuals with a particular interest in a certain aspect of resilience (e.g. architectural earthquake resilience, resilience in coastal communities, climate change resilience etc.).

- **Broad measurements** include a set of different components. Usually, sources or drivers of resilience include some or many of the following measurement dimensions:

SYSTEMS	EXAMPLES
Physical	• Critical infrastructure • Communication systems
Human	• Skills • Knowledge • Health • Education
Social	• Community networks • Trust • Civic engagement • Norms
Political	• Disaster risk reduction plans
Institutional	• First responders • Response system
Technical	• Early warning systems • Emergency plans
Economical	• Income • Productivity
Food & Nutrition	• Food security
Poverty	• Poverty levels
Environmental	• Fresh water • Arable land
Ecological	• Pollination • Carbon sinks

Source: adapted from Gall 2013, p.16

RESILIENCE AS A SYSTEM

Resilience is frequently described as a '**system'** or a '**system of systems'.** A systems approach usually refers to a view of resilience as a **self-regulating** system – or cluster of systems - that are self-correcting through feedback. Such complex adaptive systems that create resilience share synergies, linkages and interactions across spatial and temporal scales (*Gall 2013, p.18*).

This has **implications** for **measuring** disaster resilience: A system-wide approach to resilience needs to capture 'a range of activities, actors and processes that are part of a resilience building system', as UNDP concludes (UNDP 2013, p.7).

A coherent system approach has - as an analyst recently observed – **yet to materialize** (*Gall 2013, p.22*), but some attempts have been made recently: A scoping study by the ***OECD*** looked at the various components of a resilient system and how to measure it (Mitchell 2013). The ***Network of Adaptive Capacities*** understands community resilience as a process – not as an outcome - linking a network of adaptive capacities to adaptation after a disaster. The ***DFID/TANGO model*** looks at food security resilience through a systems lens, but without defining detailed indicators (*Frankenberger et al 2012*).

4. What is the smallest unit of analysis?[5]

Disaster resilience measurements use different units of analysis. The most common approach is a **geographic scale** from individual and household level to sub-national, national and global level.

GLOBAL	• The highest level of measurement is **global**. No detailed measurement framework uses this approach, but some indicators can provide data on this, for example the *'% of global economy invested in risk reduction*' or the '*No. of human global human losses due to disasters per year*'.
NATIONAL	• A common high level measurements use the **country** as the smallest unit of analysis. The typical feature of this type of data is that it cannot be broken down to sub-national geographic areas. Examples for indicators on national data are '*Annual government spending on humanitarian relief in USD'* or *'% of GDP produced in areas exposed to natural hazards'.* Examples for national-level measurements are the ***Hyogo Framework for Action Monitor*** and its possible post-2015 successor, the ***WorldRiskIndex***, the ***Global Focus Model***, the ***Prevalent Vulnerability Index*** by the Inter-American Development Bank, the ***Risk Reduction Index***, the ***Country Resilience Rating*** and the proposed ***OECD-DAC methodology for measuring resilient systems***.
SUB-NATIONAL	• Another common measurement uses a sub-national region - a 'community' - as the smallest unit of analysis. Sub-nation measurements usually take three forms: a) using **political** boundaries (e.g. county, district), b) distinguishing between **urban and rural** (e.g. cities), c) defining a geographic area with shared **characteristics** (e.g. DARA's Representative Territorial Units'). Indicators for sub-national measurements are e.g. the '*% of buildings in urban areas that comply with building standards aimed at disaster resilience''* or the *'% of communities with a disaster risk reduction plan'*. Operational sub-national level resilience measurements are for example the ***Resilience Capacity Index***, the ***Baseline Resilience Indicators for Communities***, ***ResilUS*** and the ***Indonesia Disaster Recovery Index***.
HOUSEHOLD/ INDIVIDUAL	• The smallest unit of analysis is the household or the individual. Typical examples for indicators are the '% of households assets lost due to natural hazards', the '% of people with rain-dependent livelihoods at risk from drought' or the '% of people with access to modern early warning systems'. Examples of measurement frameworks that – at least in some cases – collect data on the household or individual are the ***DRLA/UEH Evaluation Resilience Framework*** for Haiti and the ***Community Based Resilience Analysis (CoBRA)***.

[5] partially adjusted from Mitchell et al 2013, p.xii

C. CHARACTERISTICS OF THE MEASUREMENT

1. Is the measurement inductive or independent?

A key distinction between resilience measurements is the overall approach taken to quantifying resilience. Attempts to measure disaster risk include (1) the 'inductive' approach, whereby one establishes a set of **characteristics ('inductive')** which are judged to be relevant to resilience, and attempts to measure these; and (2) the '**deductive'** approach, where **independent** measurements are used.

INDUCTIVE MEASUREMENTS: CHARACTERISTICS OF RESILIENCE

Most current attempts to measure disaster resilience define a set of desired **characteristics** or **attributes** for individuals, households, communities, systems, regions or countries that are considered resilient. This method is typically rooted in **practical experience** using a bottom-up approach, and/or based on general **theories** on what resilience is. In most measurements, characteristics include two or multiple attributes capturing physical, economic, social, political, institutional, etc. dimensions of resilience capacities.

The obvious **advantage** of an inductive approach is that it can easily be **adapted** to different geographic settings, cultures, environments, etc. But this advantage has a downside: The choice of combinations of specific characteristics as proxy for resilience tends to be **case-specific** and cannot easily be generalized. In addition, inductive measurements are often emerging from a specific **discipline** and tend to remain biased towards it (e.g. climate change, engineering, food and nutrition, floods).

The most significant weakness of an inductive method to resilience measurement is the **circular logic** of such an approach: *'If we define a priori the variables that lead to system resilience, then our conclusions will be largely driven by our initial selection of variables'* (Cumming 2005, p.976).

THE CIRCULAR ARGUMENT OF RESILIENCE CHARACTERISTICS

THE CONTEXT: As an NGO regional director in the Sahel region, John Smith (JS) leads a program that aims at 'strengthening the resilience' of communities to climate change.

THE METHODOLOGICAL ISSUE: Resilience cannot be measured directly – JS therefore needs to 'construct' a Resilience Index. For that he combines together several household and community variables, which he expects – based on his long field experience – are important for resilience. In particular amongst these JS includes a Livelihood Diversification Index (LDI), so that *Resilience Index = f(LDI, other characteristics)*.

THE INTERVENTION: JS's team designs and implements a series of activities with the explicit objective to help the targeted communities to diversify their households' livelihood strategies – as an attempt to strengthen their resilience.

TESTING THE IMPACT: After three years, JS now needs to demonstrate the impact of his project on the resilience of the targeted communities. For this he compares the Resilience Index before the intervention (using the baseline data he had collected) and after the intervention. Since the level of livelihood diversification of the households has (hopefully) been improved through the project activities, the post-project LDI is likely to be greater than the pre-project (baseline) LDI, i.e. *LDI_before < LDI_after*, thus transmitting mechanistically this change to the RI. The project evaluation shows indeed that: *Resilience Index before < Resilience Index after*.

WRONG CONCLUSION: Since the data shows that *Resilience Index before < Resilience Index after*, JS concludes that his initial hypothesis was correct: households' resilience can be strengthened by helping these households diversify their livelihoods. This conclusion however is incorrect: what the empirical data shows is in fact that the project has effectively improved the households' level of livelihood diversification – it does not prove that the intervention has actually improved resilience.

Source: adapted from Béné 2013, p.8, theoretic example

INDEPENDENT MEASUREMENTS

Robust independent measurements complement circular measurements. Since they are independent from household or community characteristics, they can be used to **test and validate an inductive approach.** What would be required for that is a set of *independent* indicators of resilience that '*are not directly derived from the characteristics of the specific households or communities which are to be tested*' (Béné 2013, p.7)

This review has only found few attempts to mitigate the potential circular fallacy of an inductive approach using independent measurements.

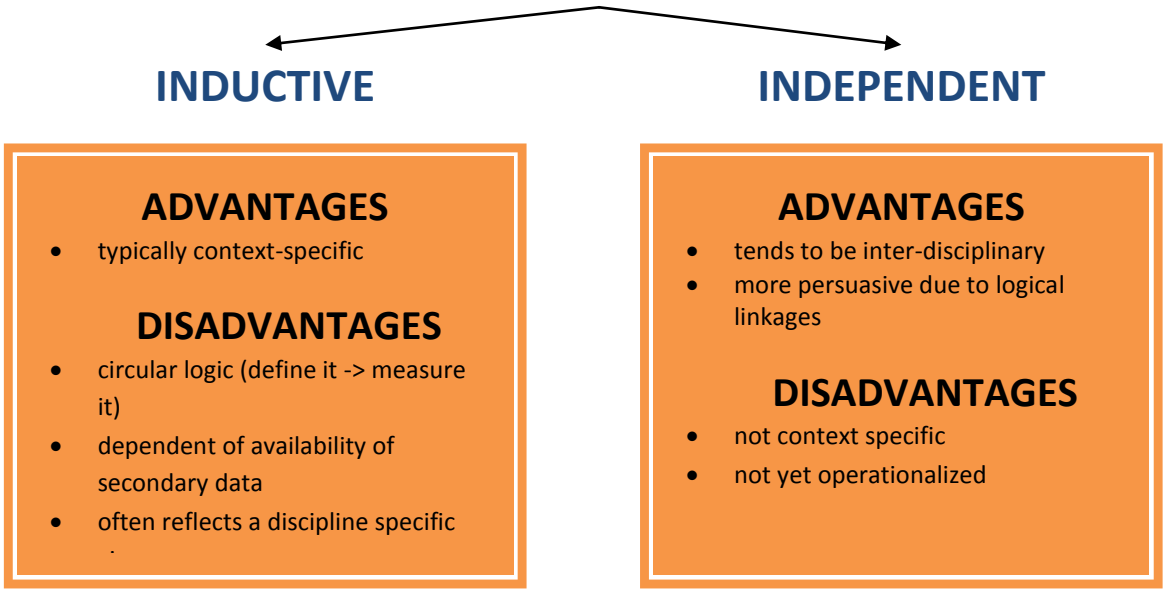
- **RESILIENCE COST**: An example of a possible independent measurement of resilience is the ***resilience costs approach*** (understood to include social, psychological or ecological 'costs'). This includes a) ex-ante investments to prepare for disasters, b) costs of destruction, and c) ex-post costs of recovery, including replacement costs, costs for emergency assistance and costs associated with adaptation and transformation (Béné 2013, 11-12).

- **SUBJECTIVE SURVEYING:** Instead of defining resilience characteristics, different stakeholders are surveyed on their subjective perception of disaster resilience, risk and vulnerabilities.

These surveys use standardized survey questionnaires or iterative approaches like the Delphi technique.[6] Examples for resilience measurements are the planned ***Country Resilience Rating*** by the World Economic Forum, UNDP's ***Community Based Resilience Analysis (CoBRA)*** and – at least partially – DARA's ***Risk Reduction Index (RRI)***.[7]

CONCLUSION

Currently, the predominant approach in measuring disaster resilience has been the **inductive approach**. Defining a set of characteristics has the advantage of being tailored to a specific context. However, it risks the fallacy of circular logic (where the resilience is measured using the very same characteristics that, it had been proposed, are *key* elements of resilience), typically depends on the availability of secondary data and often reflects a discipline specific view. One way to validate a measurement approach based on a set of resilience characteristics is to corroborate it with **independent** measurements. However, few attempts have been made so far to overcome measuring disaster resilience *ex ante*, and none has been widely tested yet. (see e.g. *Béné 2013*).



Source: adapted from Béné 2013

[6] an approach using a the iterative use of a panel of experts
[7] partially based on Mitchell 2013

2. Is the measurement standardized or tailored to the context?

Resilience measurements use **standard metrics**, tailored **context-specific metrics** or a **combination** of both:

- **Standard metrics** are general enough to permit comparison of different communities or countries. However, they are not flexible enough to capture local conditions and circumstances. The majority of resilience measurements covered in this review fall under this category.

- **Context-specific** metrics are tailored to countries, communities or groups of households or individuals. Examples are the ***DRLA/UEH Evaluation Resilience Framework*** for Haiti, the ***Minimum Characteristics of NRRC*** in Nepal or the ***Country Disaster Resilience Index (CDRI)*** for coastal communities in the United States.

- Resilience measurements can also use a **blended** approach with a core set of standard indicators and additional, locally tailored measurements. An example of a blended approach is UNDP ***Community Based Resilience Analysis (CoBRA),*** which includes surveys and key informant interviews. DARA's ***Risk Reduction Index*** has a strong qualitative focus using questionnaires to systematically gather perceptions about underlying risks; perception information is corroborated with secondary data, resulting in a mixed-method approach.

Another way to tailor disaster resilience measurements is the use of **participative processes**. While most measurements of disaster resilience and risks currently rely on quantitative secondary data, the inclusion of **perceptions** can add more context-specific elements, for example through the use of **self-assessments**. While potentially useful as a supplement to objective data, the value of self-assessments remains limited on their own, as they are by definition subjective, and do not allow for cross-country comparison. ***The World Economic Forum*** combines perception indicators from the Forum's Executive Opinion Survey with quantitative indicators from secondary sources on response and recovery. The monitoring system of the ***Hyogo Framework for Action***, for example, is based nearly exclusively on self-assessment by governments.

3. How mature is the measurement?

While in some programmes and some locations efforts to address disaster resilience will be at an advanced stage, in others the first tentative steps are now being taken. This review includes the full range of maturity, from early models yet to have a developed indicator framework, to models that already have institutionalized disaster resilience measurements and are collecting data frequently.

The development of a measurement framework for disaster resilience (=the maturity of the measurement) typically follows **six phases of maturity**:

LEVELS OF EMPIRICAL KNOWLEDGE	*EXAMPLES*
Phase 1: a **theoretic framework** for measuring resilience exists, but no indicators are defined yet	***OECD-DAC methodology for measuring resilient systems***, ***Resilience costs approach*** by IDS, ***MEERC R4 Resilience Framework***, ***Network of Adaptive Capacities***
Phase 2: a theoretic framework for measuring resilience exists and at least some **potential indicators** are suggested to measure disaster resilience	***Post-2015 indicators for Disaster Risk Reduction***
Phase 3: a clear **indicator framework** based on a theoretic framework has been defined, but data for the indicators is not collected systematically	***Country Resilience Rating*** by the World Economic Forum, ***PEOPLES Resilience Framework***, ***Community Based Resilience Analysis (CoBRA), Minimum characteristics of NRRC***
Phase 4: as above, but at least some **data for the indicators** or data for a **limited geographic area** has been collected	DARA's ***Risk Reduction Index, Baseline Resilience Indicators for Communities*** (BRIC) and ***ResilUS*** (US only), the ***DRLA/UEH Evaluation Resilience Framework for Haiti***, the Indonesia ***Disaster Recovery Index*** (DRI)
Phase 5: as above, but the data collection for the indicators is **institutionalized** and data is collected **regularly**	***Hyogo Framework for Action Monitor***, UNU's ***WorldRiskIndex***, OCHA's ***Global Focus Model*** (GFM), Maplecroft's ***Socio-Economic Resilience Index*** *(but data not public),* ***Resilience Capacity Index*** (RCI)
Phase 6: the measurement has been **empirical verified**	*to our knowledge, no general measurement framework for disaster resilience has been empirically verified yet*

4. Is it an actual measurement or a model?

It is a well-known difficulty of measuring disaster-related changes that outcomes (and impact) can **only be observed in the event of a disaster**. To overcome this limitation, some resilience measurements make use of **probabilistic risk models**.

PROBABILISTIC RISK MODELS

'[Probabilistic risk models] simulate the losses from thousands of possible events, allowing for an assessment of the damages expected in a given year. These have many advantages, not least of which is the ability to project the impact (and therefore imply the effectiveness of DRM strategies) of disasters on a given population and over a specific time period. This can look at the effects of disasters on a number of variables, including number of deaths, economic losses and levels of poverty. Models also offer the opportunity of assessing preparedness for high-impact low-probability events, a factor that observational records may struggle to adequately account for given the possible 15-year time period of the post-2015 goals.'

Source: Mitchell 2013, p.xii.

Probabilistic modelling is mostly used when measuring **disaster *risks***: The ***Global Earthquake Model*** (GEM, www.globalquakemodel.org) is the first working global earthquake model, with global, open-source risk assessment software and tools. It was constructed by a public-private partnership initiated by the Global Science Forum of the OECD, and attempts to provide an authoritative standard for calculating and communicating earthquake risk. The ***Central American Probabilistic Risk Assessment Platform*** (CAPRA, www.ecapra.org) by the World Bank is a Disaster Risk Information Platform for use in decision-making that is based on a unified methodology and tools for evaluating and expressing disaster risk. Building on—and strengthening—existing initiatives, CAPRA was developed by experts to consolidate hazard and risk assessment methodologies and raise risk management awareness.

Among the disaster **resilience** measurements, ***ResilUS,*** for example, focuses on **recovery and loss estimation** using random Monte Carlo methods.[8] The proposed UNISDR ***post-HRA*** indicators are expected to include likely future losses through metrics like the **Annual Average Loss** (AAL) or the **Probable Maximum Loss** (PML) models, modelled **economic losses** based on the Global Assessment Report on Disaster Risk Reduction 2013, and **global hazard** models.

[8] algorithms relying on repeated random sampling

D. MAPPING

MEASUREMENT	Developer/ Affiliation	Focus	Components	Smallest unit of analysis	Methodology	Participatory	Data sources	Stage of development
NATIONAL LEVEL								
Hyogo Framework for Action (HFA) Monitor	**UNISDR** (globally)	progress towards HFA using 31 indicators on three levels (outcomes, goals, priorities)	indicators for the outcome, three strategic goals and five priority areas	local government or country	self-assessment by governments on scale from 1 to 5; mostly input-related	yes (self-assessment)	primary (self-assessment)	**IMPLEMENTATION; 2009, 2011 and 2013**
WorldRiskIndex	**UNU-EHS**	disaster risk value for 173 countries	exposure, susceptibility, coping capacities, adaptation	country	quantitative; weighted composite index with 28 indicators	no	secondary data only	**IMPLEMENTATION**; annually since 2011
Global Focus Model (GFM)	**UN OCHA & Maplecroft**	hazards, vulnerabilities and response capacity at country-level	hazard, vulnerability, capacities, humanitarian need	country & region	quantitative; weighted composite index	no	secondary data only; some data from proprietary indices of Maplecroft	**IMPLEMENTATION; annually since 2007**
Socio-Economic Resilience Index	**Maplecroft**	socio-economic resilience as part of a set of natural hazards risk atlas	*not known*	country	*not known*	no	*not known*	**IMPLEMENTATION; at least since 2011; only paid access**
Risk Reduction Index (RRI)	**DARA**	measurement of underlying risks; so far Latin America and Western Africa	environment and natural resources, socio-economic conditions, land use and the built environment, governance	country	mostly qualitative; local perceptions about underlying risk using key informants	yes (perception surveys)	primary data (questionnaire, workshops)	**IMPLEMENTATION; partially since 2010**
Prevalent Vulnerability Index (PVI)	**Inter-American Development Bank**	part of a set of four indicators that measure the potential impact of natural hazards	exposure, susceptibility, socioeconomic fragility and resilience	country (but also sub-national)	composite index consisting of 3 sets of 8 high-level indicators	No	secondary data only	**IMPLEMENTATION; partially in Latin America**
Country Resilience Rating	**World Economic Forum**	resilience of countries to global risks	robustness, redundancy, resourcefulness, response and recovery	country	mix of quantitative (mostly existing indices) and perception data	yes (perception surveys)	secondary data and perception surveys	**INDICATORS DEFINED**
AGIR Results Framework	AGIR	food and nutrition resilience in Sahel and West Africa	4 impact indicators and a set of outcome indicators for 4 objectives	country	quantitative and qualitative set of individual indicators for each objective	No	secondary data; indicators drawn from existing programmes and initiatives	**INDICATORS DEFINED**
Post-2015 indicators for Disaster Risk Reduction	**UNISDR**	disaster Risk Reduction including economic resilience	not defined, but might refer to economy, capital stock, investment and saving levels, trade flows, insurance penetration, fiscal resilience, social protection etc.	*not defined yet*	*not defined yet*	no	secondary data only	**PLANNING**; indicators only partially defined

MEASUREMENT	Developer/ Affiliation	Focus	Components	Smallest unit of analysis	Methodology	Participatory	Data sources	Stage of development
SUB-NATIONAL LEVEL								
Resilience Capacity Index (RCI)	**Network on Building Resilient Regions (BBR)**	single statistic summarizing a region's score on 12 equally weighted indicators in US	economic, socio-demographic, community connectivity capacities	communities in U.S.	numeric indicators; some use of existing composite indicators	no	secondary data only	**IMPLEMENTATION: data for USA**
Baseline Resilience Indicators for Communities (BRIC)	**Hazards & Vulnerability Research Institute, Univ. of South Carolina**	set of indicators based on the Disaster Resilience of Place (DROP) model	ecological, social, economic, infrastructure, Institutional, competencies	communities	numeric and yes/no indicators; use of existing composite indicators	no	secondary data only	**IMPLEMENTATION; partially in South Carolina, USA**
ResilUS	**Huxley College of the Environment, Western Washington University**	prototype simulation model of community resilience in U.S.	recovery module, loss estimation module	communities in U.S.	*not known*	probabilistic methods	secondary data only	**IMPLEMENTATION; prototyping in 3 study areas**
Tsunami Recovery Impact Assessment and Monitoring System (TRIAMS)	**Indonesia, Sri Lanka, Maldives, Thailand, IFRC, WHO, UNDP**	common approach to monitoring recovery efforts and assessing impact in four countries affected by the 2004 tsunami in Asia	vital needs, basic social services, infrastructure, livelihoods	Indonesia, Sri Lanka, Maldives, Thailand	28 quantitative output indicators, 20 outcome indicators and 3 impact indicators on recovery	includes qualitative tools in addition to indicators	secondary and primary data; qualitative data for triangulation	**IMPLEMENTATION;** (in *Indonesia, Sri Lanka, Maldives, Thailand)*
DRLA/UEH Evaluation Resilience Framework for Haiti	**Tulane University / University of Haiti**	model to measure the relationship between a shock, humanitarian assistance and resilience	wealth, debt and credit, coping behaviours, human capital, protection and security, community networks, and psychosocial status	households	quantitative composite indicators and qualitative tools	yes (surveys)	primary data (surveys & focus groups)	**IMPLEMENTATION *(in Haiti)***
Indonesia Disaster Recovery Index (DRI)	**Government of Indonesia**	measurement of recovery after volcano eruption and floods in Indonesia	22 recovery variables	communities in Indonesia	Household survey and longitudinal data	*not known*	primary data (household surveys)	**IMPLEMENTATION *(in Indonesia)***
FAO Resilience Tool	**FAO**	root causes of household vulnerability	assets, income and food access, access to basic services, social safety, adaptive capacity, stability	communities	Quantitative indicators combined into an overall 'resilience score'	No	secondary data only	**IMPLEMENTATION *(in selected areas)***
Livelihoods Change Over Time (LCOT)	**Tufts University, Mekelle University**	ability to "bounce back" from major regional food security crises in Northern Ethiopia	three types of analysis: a) household welfare over time, b) food security dynamics, c) poverty traps	households	Quantitative indices; poverty traps framework from Carter & Barrett	Yes (self-reports)	secondary and primary data (four rounds of a household survey over two years)	**IMPLEMENTATION *(in selected areas)***
PEOPLES Resilience Framework	**Multidisciplinary Center for Earthquake Engineering Research**	comprehensive measurement framework building upon MEERC R4 resilience framework	population & demographics, environmental/ ecosystem, services, infrastructure, lifestyle, economic, social-cultural	communities	mix of quantitative data; use of existing composite indicators	*not known*	secondary data only	**POTENTIAL INDICATORS IDENTIFIED**

Community Based Resilience Analysis (CoBRA)	**UNDP Drylands Development Centre**	universal and context-specific measurement framework for resilience	survival and livelihood protection threshold; physical, human, financial, natural and social	households (for meta-indicator), Communities	numeric and yes/no indicators; qualitative data	yes (interviews, focus group discussions)	primary data collection in combination with secondary data	**POTENTIAL INDICATORS IDENTIFIED**
Minimum characteristics of NRRC	**Nepal Risk Reduction Consortium (NRRC)**	suggested indicator framework on the output level	institutional, information, assessments, teams, plans, funding, infrastructure, warning systems	communities in Nepal	mostly yes/no and numeric indicators	no	primary data collection required in most cases	**POTENTIAL INDICATORS IDENTIFIED**
USAID resilience domain framework	**USAID**	results matrix with a set of indicators for 3 objectives and the goal	income & food access, assets, adaptive capacity, social capital and safety nets, governance, nutrition and health	communities	numeric indicators	yes (self-perception survey)	secondary and primary (surveys) data	**POTENTIAL INDICATORS IDENTIFIED** *(piloted in Kenya and Ethiopia)*
Expert Consultation on Resilience Measurement for Food Security	**FAO/WFP**	proposed framework for measuring food security resilience	four set of indicators for a) baseline well-being and basic conditions, disturbances, response, and end-line well-being	*not known*	numeric indicators	no	secondary data	**INDICATORS DEFINED**
ODI disaster risk management indicators	**ODI**	indicators and targets for disaster risk management in post-2015 development goals with an emphasis on economic impacts	indicators on impact, outcomes, outputs and inputs for international, national, sub-national and local level	individuals, households and community	numeric sets of individual indicators organized by levels in a matrix	no	secondary data only	**INDICATORS DEFINED**
Basket of indicators of economic resilience	**London School of Economics and Political Science**	economic lens to complement more direct humanitarian and poverty reduction goals	set of 10 economic indicators on input, output, outcome and impact level	communities	numeric indicators	no	secondary data only	**INDICATORS DEFINED**
Resilience costs approach	**Institute of Development Studies (IDS)**	measurement of costs of resilience (incl. social, psychological, ecological, etc).	ex-ante investments, cost of destruction, ex-post costs of recovery	households and communities	*not known*	*not known*	*not known*	***NO MEASUREMENT FRAMEWORK***
MEERC R4 Resilience Framework	**Multidisciplinary Center for Earthquake Engineering Research**	measurement framework with a focus on infrastructure	robustness, redundancy, resourcefulness, rapidity	communities	*not known*	*not known*	*not known*	***NO MEASUREMENT FRAMEWORK***
Network of Adaptive Capacities	**Norries 2008**	theory of community resilience	economic, social, information & communication, community competences	Communities	*not known*	*not known*	*not known*	***NO MEASUREMENT FRAMEWORK***

D. RECOMMENDATIONS

Based on an in-depth analysis of existing and emerging disaster resilience measurements and related literature, the following lessons can be drawn:

- **WHAT GETS MEASURED GETS DONE**

  Resilience measurement needs to be clearly and directly linked to the set targets. Measurements are not neutral tools, but influence the type of disaster risk management activities. Setting weak or selective indicators can negatively influence disaster resilience. Disaster resilience measurements need to "*monitor and incentivise both ex-ante and ex-post actions and ones that support action to reduce extensive (small scale, more common) and intensive (high magnitude, less common, more headline grabbing) disaster risk*." (Mitchell/Jones, Lovell/Comba 2013, p. ix)

- **MEASURE IMPACT AND OUTCOMES COUPLED WITH INPUTS AND OUTPUTS**

  As with other development interventions, limiting resilience measurements to one or two levels of the result chain is not conducive to obtaining a full picture of realities. Resilience needs to be understood and measured as a process *and* an outcome (*Cutter 2011*). A major review of post-2015 disaster management concludes: '*An outcome-related target [...] coupled with a set of input/output indicators to guide action, appears one of the most compelling formulations.*' (Mitchell et al 2013, p.ix).

- **MEASURE ALL DIMENSIONS**

  If resilience is a 'system of systems', different dimensions of resilience can influence each other. That is why there is a need to capture all relevant dimensions of resilience. There is a '*need for a multi-scale, generic, and multi-dimensional metric'* for resilience (*Béné 2013)*. This can includes physical, human, social, political, institutional, technical, economical, ecological, environmental dimensions, food security and nutrition, poverty, and so on.

- **COMBINE STANDARD AND TAILORED MEASUREMENTS**

  While standard resilience measurement lend themselves well to comparisons, measurements tailored to a community, area, region or country better reflect the specific context of resilience. A combination of both standard and tailored measurements results in the most complete picture, combining the advantages of standard and tailored measurements.

- **COMBINE MEASURING ACTUAL OUTCOMES WITH PROBABILISTIC MODELLING**

  The combination of observational data on actual outcomes following disasters and data yielded from modelled techniques appears to be the most promising approach: *'Risk and resilience models can be used in parallel to demonstrate annual progress, and help inform future policy. Simple transparent risk models can be particularly useful as a complementary tool '* (Ranger/Surminski 2013, pp.16-17).

ANNEX

NATIONAL LEVEL MEASUREMENTS

Hyogo Framework for Action Monitor

A set of recommended **indicators** for implementing the Hyogo Framework for Action (HFA) was set up in 2008. The Hyogo Framework for Action (HFA) is monitored through the HFA Monitoring and Progress Review process (www.preventionweb.net/english/hyogo/hfa-monitoring/).

The HFA monitoring system relies on **three levels of indicators**:

- 3 numeric, high-level outcome indicators (deaths arising from natural hazard events, economic losses, people affected by natural hazard events)
- 7 yes/no indicators for the 3 strategic goals
- 22 yes/no indicators for the 5 priority areas

Apart from the numeric outcome indicators, all other indicators are **yes/no** indicators. The guidelines suggest the use of a **5-point scale** for a more nuanced assessment of progress.

Table 1: Five-level assessment tool for use in grading achievement of qualitative factors in indicators

Level	Generic description of achievement	Examples of an assessment of the indicator "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."*

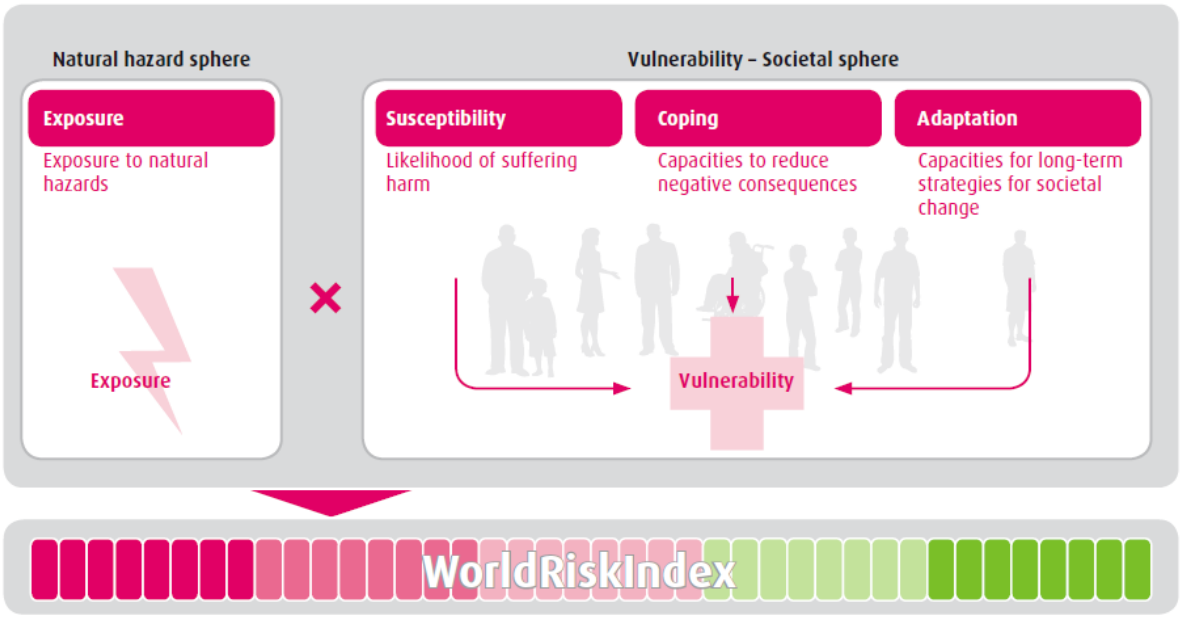
Source: ISDR 2008, p.10

The monitoring framework relies – with the exception of the 3 numeric indicators - on a **self-assessment by governments**, which remains by definition subjective. This does not allow for inter-country comparison. From the perspective of governments, basically all indicators are on the **input or output level**. Nearly all indicators on the level of 'goals' refer to national policies, plans and programmes. The low-level priority indicators are mostly referring to various activities considered to help reduce disaster risk. Element of **resilience** are captured at the level of goals (mostly national policies) and priorities (activities).

WorldRiskIndex

The WorldRiskIndex identifies and ranks regions and countries that face a high disaster risk. The index uses **28 indicators** to calculate and compare **risk values for 173 countries.** The index is designed and tracked by the Institute for Environment and Human Security (EHS) of the United Nations University (UNU). The index is reported on in the World Risk Report (www.worldriskreport.com/)

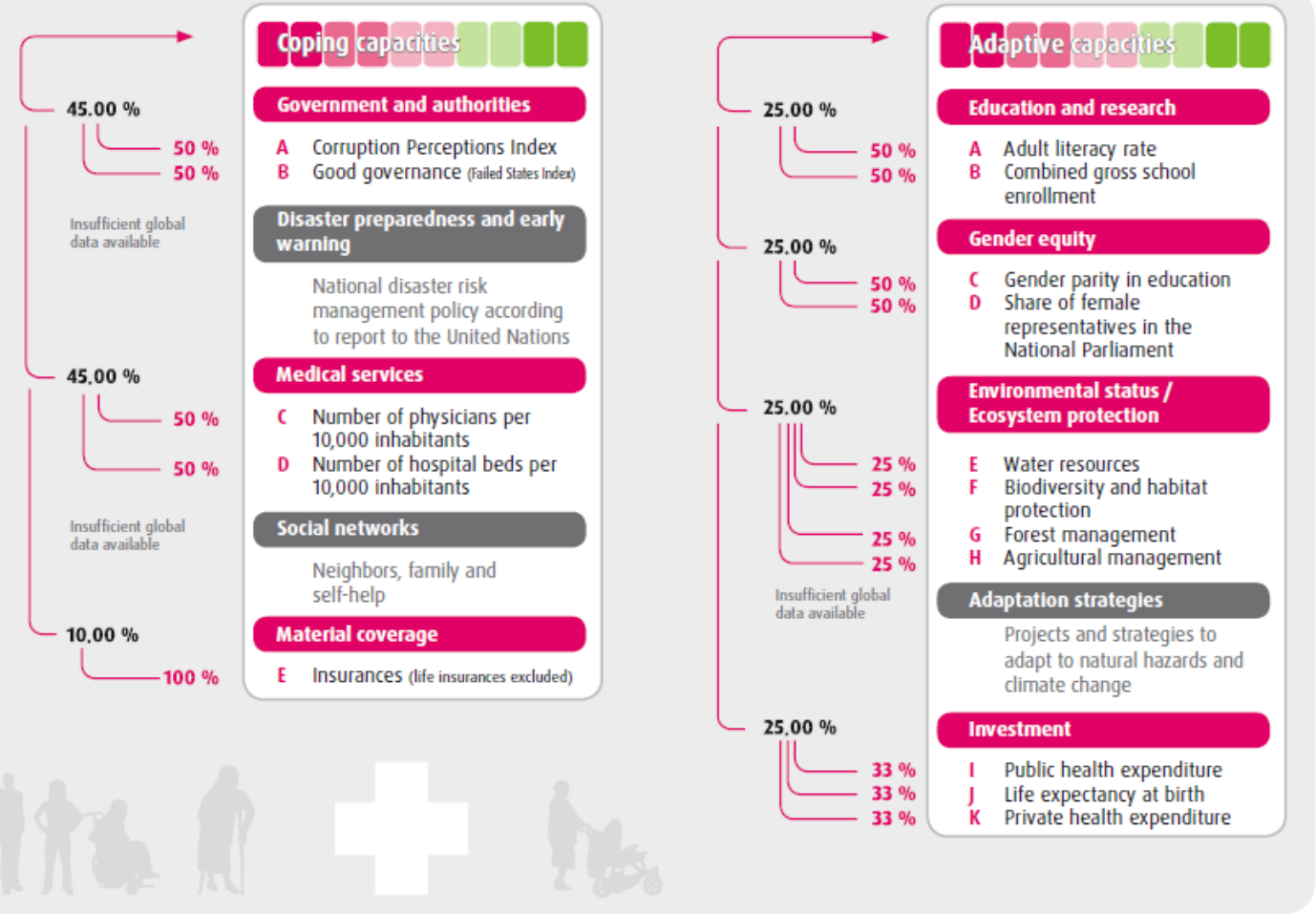
The composite index consists of a set of indicators that track natural hazards (the natural hazard sphere) and vulnerabilities (the societal sphere):



Countries are ranked based on **four key components** that take both natural hazards and social factors into account.

- **exposure** to natural hazards and potential risks
- **susceptibility** as the likeliness of suffering harm, susceptibility as a function of public infrastructure, housing conditions, nutrition, poverty and dependencies, and economic capacity and income distribution
- **coping capacities** related to governance and authorities, disaster preparedness and early warning, medical services, social networks and material coverage
- **adaptive capacities** related to education and research, gender equity, environmental status and ecosystem protection, adaptation strategies and investments

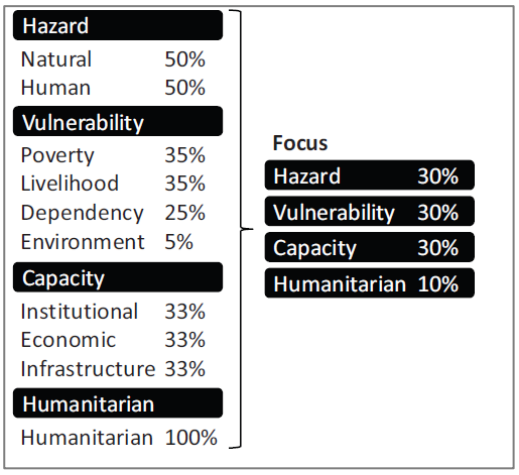
The third and fourth component – coping capacities and adaptive capacities - directly relate to **resilience capacities**. The index makes use of existing composite indicators such as the Corruption Perception Index and the Failed States Index as well as standard high-level development measurements like the adult literacy rate or the share of female representatives in parliament.



Key resources:

- Indicators for the WorldRiskIndex (Global scale), www.worldriskreport.com/uploads/media/Indicators_for_WRI_final_draft_01.pdf

Global Focus Model (GFM)



OCHA developed a risk model in 2007 to analyze natural and human-induced **hazards**, **vulnerabilities** and **response capacity** at the **country-level** using a range of quantitative indicators. Since then, the model has been adopted as a corporate risk model and updated each year as part of OCHA's annual work planning cycle. The 2012 Global Focus Model (GFM) has been rebuilt in conjunction with Maplecroft (www.maplecroft.com)

The Global Focus Model is designed to answer several **core questions**: Which populations are most exposed to hazards that could trigger a humanitarian emergency? What factors influence a hazard's impact on a population? What factors influence the ability of a community and society to cope with the impact of a hazard? To what extent is OCHA likely to have a role in a country, given the organisation's mandate, tools and services?

The model seeks to answer these questions through analysis of data in four areas: **hazards**, **vulnerability**, **capacity** and the **demand for humanitarian coordination support**. These categories follow international standards for the calculation of risk, while allowing flexibility to account for factors specific to OCHA's humanitarian mandate. The sub-index on **capacity** directly relates to resilience. The sub-index reflects capacity of government and civil society, comprising **economic health**, **institutional resilience** and **infrastructure** at equal weights:

Economic capacities (33.3%)

- **per capita GDP** using Purchasing Power Parity (PPP)
- **total GDP**

Institutional resilience (33.3%)

- **government effectiveness score** from the World Bank's governance indicators reflect the ability of a government to organise an effective response,
- **size of the military** is used as a proxy for logistical response capacity
- **civil society capacity** considers the extent of non-governmental organisations and the ability of civil society to function without hindrance from the state

Infrastructure (33.3%)

- **communication** (comprised of indicators on adult literacy rates, household electrification, rates of internet usage, mobile phone subscriptions and fixed telephone lines),
- **physical connectivity** (comprised of indicators reflecting both the absolute and relative numbers of people living distant from cities and the density of road and rail lines)

Key resources:

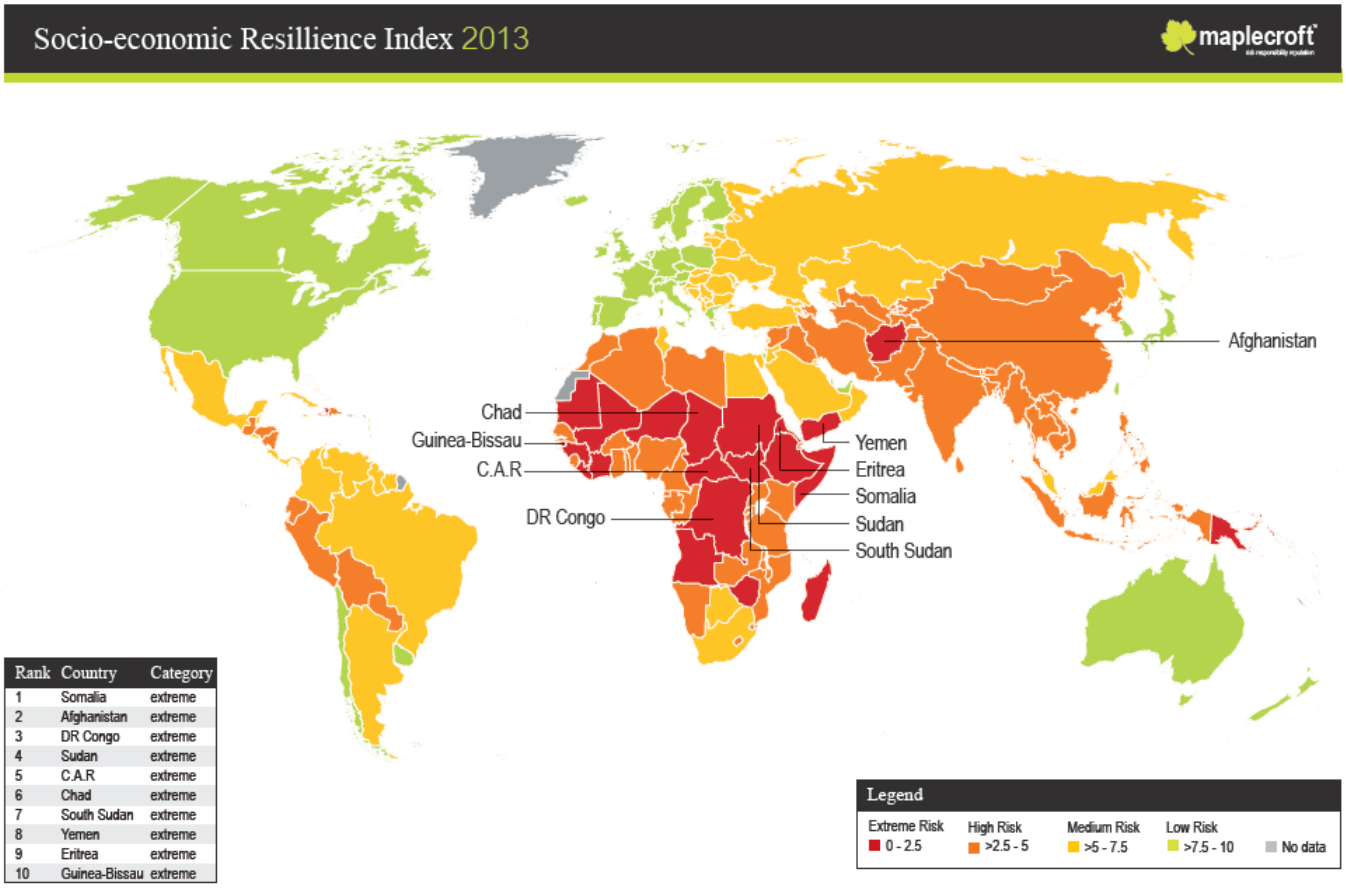
- *2013 Global Focus Model, OCHA,* www.cwger.net/wp-content/uploads/2013/10/17.-DRR-GFM-2013.pdf

Socio-Economic Resilience Index

The Socio-Economic Resilience Index is part of the **Natural Hazards Risk Atlas**, which has been developed by Maplecroft – a global risk research and forecasting company - to help organisations assess and compare natural hazards risks across **197 countries**. The atlas is only commercially available.

The index includes **29 risk indices** and interactive maps that measure **physical** exposure to 12 different natural hazards, in addition to calculating overall **economic** exposure and **socio-economic resilience** to large events.

The details of the index composition appear to be only commercially available.



Rank	Country	Category
1	Somalia	extreme
2	Afghanistan	extreme
3	DR Congo	extreme
4	Sudan	extreme
5	C.A.R	extreme
6	Chad	extreme
7	South Sudan	extreme
8	Yemen	extreme
9	Eritrea	extreme
10	Guinea-Bissau	extreme

Key resources:

- *Natural Hazards, Maplecroft , maplecroft.com/themes/nh/*
- *Socio-economic resilience index 2013, www.preventionweb.net/files/31553_socioeconomicresillianceindex2013ma.pdf*

Risk Reduction Index (RRI)

The Risk Reduction Index (RRI) measures **local perceptions about underlying risk**. The index is based on surveys conducted with **key informants** using a questionnaire in a selected number of 'Representative Territorial Units' and validated through national workshops. The index has been designed and is used by DARA international (daraint.org), a humanitarian organization based in Madrid/Spain.

The Risk Reduction Index tracks **existing conditions and capacities** for disaster risk reduction and climate change adaptation that either prevent or enable local and national actors to carry out effective risk management. Capacities are understood as **human resources** available to manage risks, while conditions are the **frameworks** (including norms, laws, legislations, codes and agreements) within which actors perform. The index uses four components ('risk drivers'):

- Environment and natural resources
- Socio-economic conditions
- Land use and the built environment
- Governance

The methodology adopted to analyse the risk drivers is fundamentally **qualitative**, although it also uses quantitative methods. On the one hand, a mixed-method approach with strong qualitative focus is employed to capture and measure perceptions of risk-related conditions and capacities at a local level. On the other hand, a quantitative approach is applied to analyse data collected from public databases.

DARA carried out an analysis of seven countries in **Central America and the Caribbean** in 2009-2010 and a second analysis for **West Africa** in 2013.

Key resources:

- daraint.org/risk-reduction-index/
- daraint.org/wp-content/uploads/2012/01/How_does_the_RRI_work.pdf
- daraint.org/wp-content/uploads/2013/10/4_QUESTIONNAIRE_EN_dist.pdf

Prevalent Vulnerability Index (PVI)

The Prevalent Vulnerability Index depicts predominant **vulnerability conditions** by measuring **exposure** in prone areas, socioeconomic **fragility** and lack of social **resilience**. These items provide a measure of direct as well as indirect and intangible impacts of hazard events. The index is a composite indicator that provides a comparative measure of a country's pattern or situation.

The Prevalent Vulnerability Index is part of a set of four composite indicators that measure the potential impact of natural hazards. These indicators of disaster risk and risk management were developed and used for an initial analysis by the Inter-American Development Bank in 2005. Although the level of analysis is the country-level, the indicators can also be applied to the sub-national level.

The index is a composite index consisting of 3 sets of 8 high-level indicators. It includes eight specific **indicators of (lack of) resilience:**

- Human Development Index (HDI)
- Gender-related Development Index (GDI)
- Social expenditures on pensions, health and education as a percent of GDP
- Governance Index (Kaufmann)
- Infrastructure and housing insurance as a percent of GDP
- Television sets per 1000 people
- Hospital beds per 1000 people
- Environmental Sustainability Index (ESI)

Key resources:

- Cardona (2007), Indicators of Disaster risk and Risk Management, updated 2007, Inter-American Development Bank, ipcc-wg2.gov/njlite_download.php?id=6132
- Cardona/Carreño (2011), Updating the Indicators of Disaster Risk and Risk Management for the Americas , in: Journal of Integrated Disaster Risk Management, IDRiM (2011) 1(1), idrimjournal.com/index.php/idrim/article/viewFile/14/PDF

Country Resilience Rating

The **World Economic Forum** proposes to assess a country's resilience using **five components**: **robustness, redundancy, resourcefulness, response and recovery**.

Each component is further defined by key attributes, and for each of these attributes, potential qualitative and quantitative indicators have been identified. The proposal is to combine for each component quantitative data from secondary sources (mostly from already existing aggregated indices) with primary data on perceptions from the World Economic Forum's well-established **Executive Opinion surveys**.

The World Economic Forum defined such a framework in a special report on national resilience of its Global Risks Report 2013.

These potential indicators are still work in progress.

Key resources:

- Global Risks Report 2013, World Economic Forum, reports.weforum.org/global-risks-2013/section-three/special-report-building-national-resilience-to-global-risks/

Resilience Components	Component Attributes	Potential Executive Opinion Survey Indicators	Potential Quantitative Indicators
Robustness	Monitoring system health	Quality of natural environment Quality of healthcare system Quality of overall infrastructure Quality of education system	Logistics Performance Index from the World Bank
	Modularity	State cluster development	Economic Freedom of the World Index from Gwartney, J., Lawson, R., & Clark, J. R. Economic Freedom of the world, 2012.
	Adaptive decision-making models	Willingness to delegate authority	Index of Economic Freedom from 2012 Index of Economic Freedom , the Heritage Foundation.
Redundancy	Redundancy of critical infrastruc-ture	Quantity of local suppliers	Reserves Renewable freshwater resources Density of physicians from World Health Statistics , World Health Organization.
	Diversity of solutions and strategy	Value chain breadth	Environmental Performance Index (Ecosystem Vitality) from Environmental Performance Index , Yale University.
Resourcefulness	Capacity for self-organization	Accessibility of digital content Extent to which virtual social networks are used	Education Index from International Human Development Indicators , United Nations Development Programme.
	Creativity and innovation	Latest technologies	Research and development expenditure as a percentage of gross domestic production from World Development Indicators, the World Bank.
Response	Communi-cation	Public trust in politicians	Media Sustainability Index from IREX.
	Inclusive participation	Business-government relations	Business regulatory environment Structural policies cluster from Country Policy and Institutional Assessment , the World Bank.
Recovery	Responsive regulatory feedback mechanisms	Reform implementation efficiency	Actionable Governance Indicators from Actionable Governance Indicators Data Portal, the World Bank.
	Active "horizon scanning"	Collaboration within clusters	Some studies have suggested potential quantitative data for this attribute including developing public-private partnerships for Research and Development and Innovation and promoting centres and networks of excellence, regional research driven clusters and innovation poles (Manjón, J. & Vicente J. A Proposal of Indicators and Policy Framework for Innovation Benchmark in Europe. In Journal of Technology Management and Innovation, 2010, 5:13-23.)

AGIR Results Framework

AGIR (www.oecd.org/site/rpca/agir/) is a global Alliance to foster improved synergy, coherence and effectiveness of resilience initiatives in the region. Launched in December 2012, AGIRs roadmap (www.oecd.org/swac/publications/AGIR%20roadmap_EN_FINAL.pdf) includes a set of key performance and impact indicators.

The objectives of AGIR and the related indicator framework focus on **food and nutritional vulnerability and resilience**. The geographic focus is on the **Sahel and West Africa**. Three out of four outcomes and the related indicators refer to food and nutrition, while one refers to social protection.

The indicators are mostly drawn from the region's **existing policies and programmes**, as well as from regional and international initiatives in which many countries in the region participate, such as the Scaling-Up Nutrition movement (scalingupnutrition.org).

SPECIFIC OBJECTIVE/PILLAR	PROCESS-PERFORMANCE INDICATORS	RESULT-IMPACT INDICATORS
Overall Objective: Structurally reduce, in a sustainable manner, food and nutritional vulnerability by supporting the implementation of Sahelian and West African policies – 'Zero Hunger' in 20 years	1. Alignment of strategies, policies and programmes with the AGIR Resilience Results Framework; 2. Establishment of a multi-stakeholder and multi-sectoral platform combining measures to enhance resilience, and of mechanisms/ frameworks for recording the results achieved by all AGIR stakeholders: financial mobilisation of states, institutions and partners in order to achieve the AGIR Results Framework; 3. Establishment of a methodological framework for taking into consideration and strengthening the role of women in food security and nutritional strategies and policies; 4. Significant increase in the share of public and private investment in structural responses to food and nutritional insecurity.	1. Prevalence of global chronic malnutrition less than 20%; 2. Decrease in the percentage of people structurally vulnerable to food and nutritional insecurity; 3. Significant increase in the coverage of food and nutritional needs by regional agricultural production (level of regional food self-sufficiency); 4. Change in the Global Resilience Index of vulnerable households, families, communities.
Pillar 1: Improve social protection for the most vulnerable communities and households in order to secure their livelihoods	1. Formulation and implementation of programmes & appropriate safety net mechanisms (number of countries that have formulated and implemented coherent food and nutritional social safety net programmes); 2. Effective establishment and functionality of the Regional Food Reserve; 3. Number of rural municipalities or local structures with functional local mechanisms providing solidarity in addressing food crises.	1. Significant increase in the proportion of vulnerable populations accessing basic social services (health, education, hygiene-water-sanitation); 2. Significant increase in the proportion of vulnerable populations that have increased their incomes and been able to invest thanks to social transfers; 3. Significant increase in the proportion of vulnerable populations with access to a balanced diet, especially during lean periods and price volatility; 4. Decrease in seasonal and inter-annual variations in the prevalence of overall acute malnutrition; 5. Reduction of at least 50% in the proportion of vulnerable populations in areas liable to major risks and shocks seeking food aid and humanitarian assistance.
Pillar 2: Strengthen the nutrition of vulnerable households	1. Formulation and implementation of structural programmes for: i) access to nutrition and health services; ii) prevention and treatment of diseases with high morbidity, mortality; iii) reproductive health; 2. Formulation and implementation of specific programmes focused on infant and young child feeding; 3. Integration of nutritional issues in other sectoral development policies: i) nutritional objectives and outcomes clearly formulated in sectoral policies; ii) an established and appropriate institutional position on nutrition; 4. Introduction of legal and financial frameworks for the implementation of nutritional priority actions in the countries.	1. Prevalence of global chronic malnutrition among children under 5 years less than 20%; 2. Prevalence of global acute malnutrition among children under 5 years less than 5% throughout the year; 3. Rate of child mortality less than 2 deaths per 10 000 children per day, and decrease in the prevalence of diseases with high morbidity and mortality; 4. Increase in the percentage of pregnant mothers and children up to 24 months (first 1 000 days of life) having a balanced diet; 5. Significant progress on spacing of births and increasing the age of first pregnancy.

Key resources:

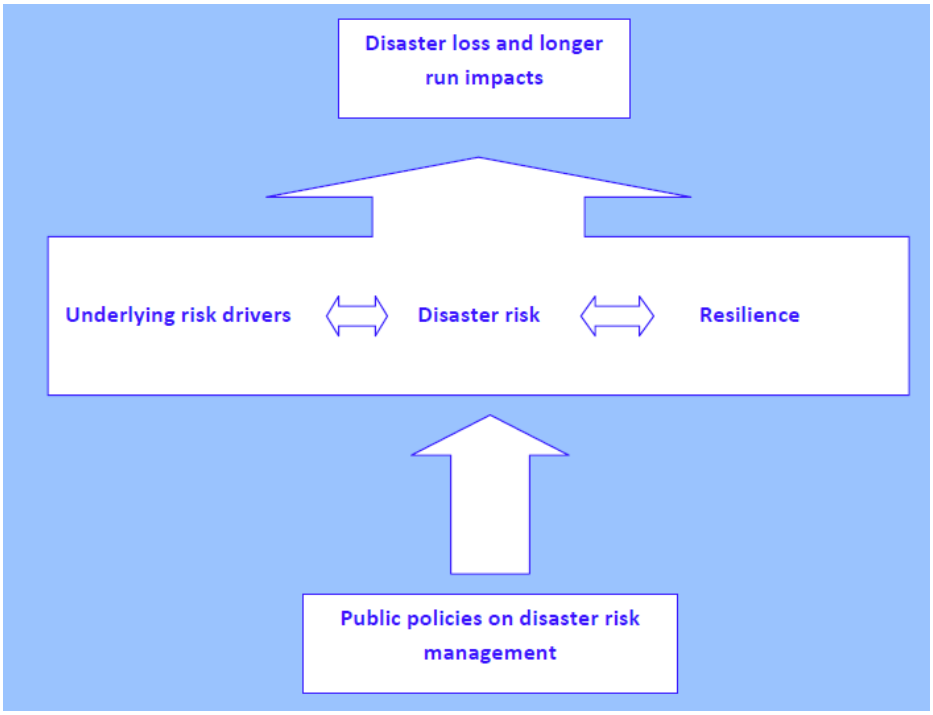
- AGIR's roadmap, www.oecd.org/swac/publications/AGIR%20roadmap_EN_FINAL.pdf

Post-2015 Indicators for DRR

In a paper from late 2013, UNISDR proposes a new system of indicators for disaster risk management, which is intended to contribute to the discussions on HFA2 and to the Third World Conference on Disaster Risk Reduction (www.preventionweb.net/english/professional/publications/v.php?id=35716)

The proposed indicator system consists of:

- **disaster loss and damage** indicators
- **risk** and **resilience** indicators
- **underlying risk drivers** indicators
- disaster risk management **policy** indicators



The indicators for **underlying risk drivers** indicators includes among its 52 indicators a set for **coping capacity** (in addition to economic and fiscal structure, poverty and social vulnerability, environmental degradation and climate change, urbanization and governance) *(see table below).*

Resilience indicators, however, are not yet clearly defined: *"This indicator family would also explore the resilience of a country's economy to probable losses. This will be done by identifying indicators that compare risk to the size of a country's economy, its capital stock, investment and savings levels, trade flows, insurance penetration, the fiscal health of government, the degree of social protection and other metrics".* (UNISDR 2013, p.4).

UNISDR plans to pilot the indicator system in early 2014 using data from 49 countries.

Key resources:

- www.preventionweb.net/posthfa/

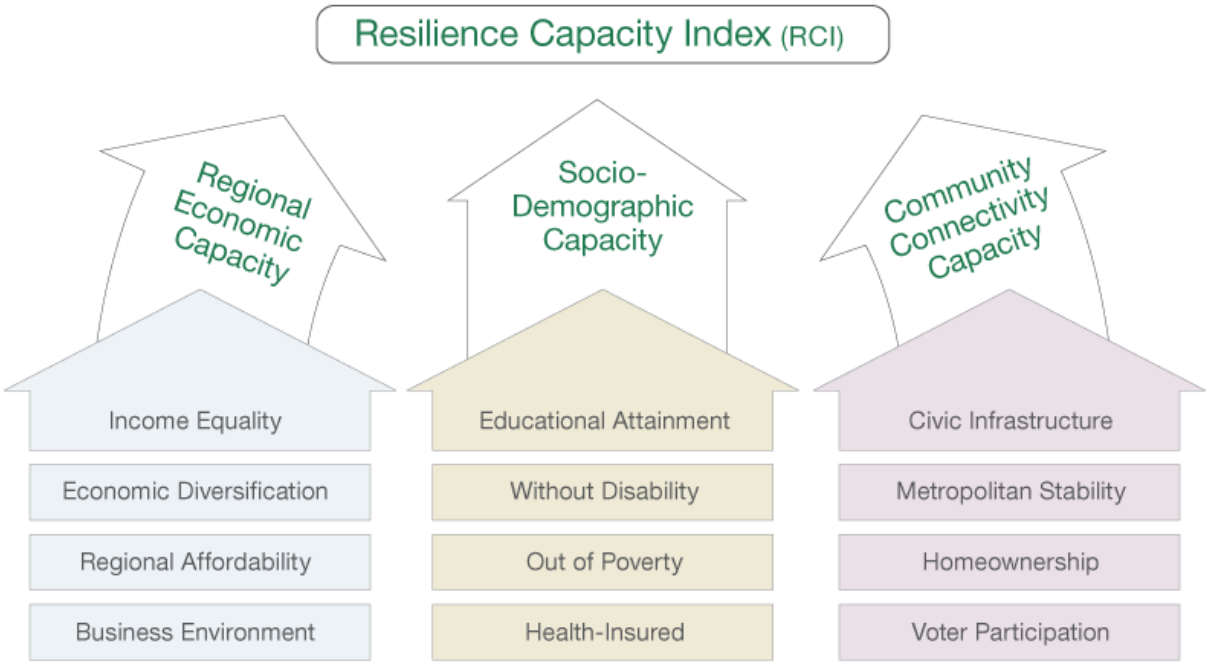
Table 1: Underlying Risk Drivers

Category	Indicator
Economic and fiscal structure	• GDP per capita (or GNI per capita), USD • GDP annual growth rate, % • Trade and Investment(balance of payments, % of GDP, trade concentration index, FDI, net inflows, % of GDP) • Industrial structure (value-added and employment of top three sectors, % of GDP, % of total employment) • Age dependency ratio, % of working-age population • Per capita net savings • Fiscal (central government debt, % of GDP, primary balance, % of GDP) • International bond rating • Per capita ODA received, USD
Poverty and Social Vulnerability	• Poverty (poverty gap at national poverty line, Gini index, unemployment rate, % of total labor force) • Human Development Index • Gender Inequality Index • Health (health expenditure, % of GDP, private insurance, % of private of private expenditure on health, life expectancy at birth) • Education (public expenditure on education, % of GDP, school enrollment, %, literacy rate, %) • Net food import ratio, %
Environmental degradation and Climate Change	• Ecological footprint • Water stress • Deforestation rate • Environmental health • Ecosystem vitality (including CO2 emissions)
Urbanization	• Population (population density, people/km2, population growth annual rate, %, urban population growth annual rate, %, population living in slums, % of urban population) • Capital (gross fixed capital formation, % of GDP, capital stock, million USD/1000km2) • Settlement (housing ownership rate, property right)
Coping Capacity	• Hospital beds per 1,000 people • Communication (Internet per 1,000 people, mobile phone per 1,000 people, percentage of households with TV) • Energy (quality of electricity supply, energy source diversification) • Road density • Quality of overall infrastructure • Public investment, % of GDP
Overall Governance	• Rule of law • Government effectiveness • Regulation quality • Voice and accountability • Control of corruption

COMMUNITY-LEVEL MEASUREMENTS

Resilience Capacity Index (RCI)

The Resilience Capacity Index (RCI) is a **single statistic** summarizing a region's **score on 12 equally weighted indicators**: four indicators in each of three dimensions encompassing regional economic, socio-demographic, and community connectivity attributes. The RCI was developed by the University at Buffalo Regional Institute, State University of New York and its director, Kathryn A. Foster.



The Resilience Capacity Index is calculated and accessible through the website **Network on Building Resilient Regions** (BRR), affiliated with the Institute of Governmental Studies at the University of California, Berkeley, at brr.berkeley.edu/rci/data/ranking/. The composite index uses **secondary** data (like the GINI coefficient for income equality) and existing indices (like the Innovation Index from Indiana Business Center).

Key resources:

- Resilience Capacity Index, brr.berkeley.edu/rci/

Baseline Resilience Indicators for Communities (BRIC)

The Baseline Resilience Indicators for Communities (BRIC) are based on the **Disaster Resilience of Place (DROP) model** that provides a conceptualization for understanding and **measuring community-level resilience to natural hazards**. Developed at the Department of Geography and Hazards & Vulnerability Research Institute at the **University of South Carolina**, USA, in 2008, the model proposes to measure **inherent community resilience** through the use of a limited set of indicators for the ecological, social, economic, institutional dimension, for infrastructure and for community competence.

Community resilience indicators

Dimension	Candidate variables
Ecological	Wetlands acreage and loss Erosion rates % impervious surface Biodiversity # coastal defense structures
Social	Demographics (age, race, class, gender, occupation) Social networks and social embeddedness Community values-cohesion Faith-based organizations
Economic	Employment Value of property Wealth generation Municipal finance/revenues
Institutional	Participation in hazard reduction programs (NFIP, Storm Ready) Hazard mitigation plans Emergency services Zoning and building standards Emergency response plans Interoperable communications Continuity of operations plans
Infrastructure	Lifelines and critical infrastructure Transportation network Residential housing stock and age Commercial and manufacturing establishments
Community competence	Local understanding of risk Counseling services Absence of psychopathologies (alcohol, drug, spousal abuse) Health and wellness (low rates mental illness, stress-related outcomes) Quality of life (high satisfaction)

The inherent resilience potion of the DROP model was operationalized and refined in 2010 in a **Baseline Resilience Indicators for Communities** metric (BRIC) together with the Community and Regional Resilience Institute (CARRI). The BRIC proposes a methodology and a set of indicators for measuring baseline characteristics of communities that foster resilience. Baseline characteristics are the **antecedent conditions within communities** before the implementation of any programs, policies, and interventions that foster resilience.

Key resources:

- Cutter/Barnes/Berry/Burton/Evans/Tate/Webb (2008a), A place-based model for understanding community resilience to natural disasters, in: Global Environmental Change 18 (2008), 598-606, lbrr.covalentwords.com/assets/docs/33.pdf
- Cutter/Barnes/Berry/Burton, Evans/Tate/Webb (2008b), Community and Regional Resilience: Perspectives from Hazards, Disasters, and Emergency Management, Hazards and Vulnerability Research Institute, Department of Geography, University of South Carolina, CARRI Research Report 1, September 2008, www.resilientus.org/wp-content/uploads/2013/03/FINAL_CUTTER_9-25-08_1223482309.pdf
- Cutter/Emrich/Burton (*no date)*, Baseline Indicators for Disaster Resilient Communities, Hazards & Vulnerability Research Institute, University of South Carolina, CARRI Workshop in Broomfield, USA, July 14-15, www.resilientus.org/wp-content/uploads/2013/03/Susan_Cutter_1248296816.pdf

Baseline Resilience Indicators for Communities (BRIC) indicators:

Ecological

% Land area in 100-year flood plain
% Land area subject to SLR
% Soil erosion
% Green space/undisturbed land
% Urban (access variable)
% Forested land cover (wildfire potential)
% Land with hydric soils (liquefaction)
% Wetland loss (ecosystem services)

Social

Racial/ethnic inequality (Abs. value of difference in % black & % white)
Educational inequality (Abs. value of difference less than 9th grade & college)
Physicians/10,000 (health access)
Elderly (%)
Social vulnerability index (SoVI)
Transport challenged (% no vehicle)
Communication challenged (% no phone)
Language competency (% ESL)
Crime rate (per 10,000)
Special needs (% pop with disabilities)
Health coverage (% pop with coverage)
Population wellness (% black infant mortality rate)

Economic

Housing capital (difference % white homeowner and % black homeowner)
Homeowners (%)
Employment (%)
Median household income
Poverty (%)
Single sector employment (% primary sector + tourism)
Female labor force participation (%)
Business size (% large >100 employees)

Institutional

Recent hazard mitigation plan (yes/no)
NFIP policies (per occupied housing unit)
Storm Ready participation (yes/no)
Municipal expenditures (fire, police, emergency services as a %)

Infrastructure

Mobile homes (%)
Shelter capacity (% rental vacancy)
Medical capacity (hospital beds/10,000)
Building permits for new construction (#)
Evacuation potential (arterial miles/mi^2)
Evacuation potential (# highway bridges)
Housing age (% built 1970-1994)

Community Competence

Political fragmentation (# local governments and special districts)
Previous disaster experience (PDD, yes or no)
Social connectivity (VOADs yes or no)
Dependency ratio (debt/revenue)
International migration (%)
Sense of place (% borne in state and still live here)
Social capital (churches/capita)
Social capital (% registered voters voting in 2004 election)
Internal migration (% outmigration)

Source: adapted from Cutter/Emrich/Burton (*no date*), Baseline Indicators for Disaster Resilient Communities, Hazards & Vulnerability Research Institute, University of South Carolina, CARRI Workshop in Broomfield, USA, July 14-15, www.resilientus.org/wp-content/uploads/2013/03/Susan_Cutter_1248296816.pdf

ResilUS

ResilUS – "Resilience United States" – is a **prototype simulation model** of **community resilience**. Based on the measurable aspects of community capital, the model operationalizes community resilience across multiple, hierarchical scales – household/business, neighbourhood, and community – in relation to a range of policy and decision variables associated with each scale. It **simulates the loss and recovery dynamics** of households, businesses, neighbourhoods, and communities ***before, during, and after a hazard event.*** ResilUS is unique in its emphasis on recovery time paths, spatial disparities, and linkages between different sectors of a community.

ResilUS simulates community loss and recovery. Currently the model focuses primarily on indicators associated with household and business well-being, such as **health, employment, productivity, and product demand**. It represents the relationship between these indicators of well-being and restoration of the built environment, such as building, road network, electrical network, etc.

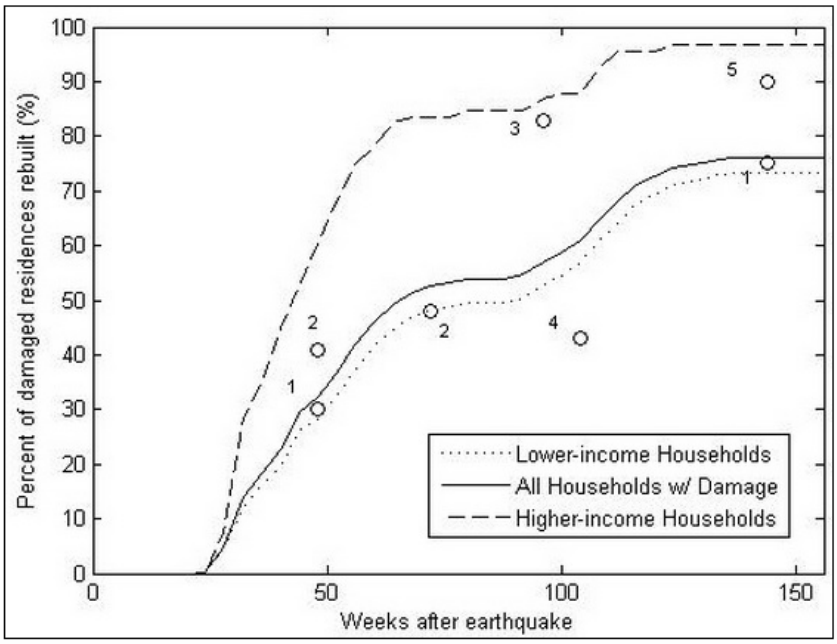


Figure 3. A graph representing the recovery of damaged low and high-income households.

ResilUS has been under development for almost a decade and has so far been applied to **three study areas**.

Key resources:

- ResilUS: Modelling community recovery from disasters, huxley.wwu.edu/ri/resilus
- www.iitk.ac.in/nicee/wcee/article/14_09-01-0095.PDF
- www.conference.net.au/cibwbc13/papers/cibwbc2013_submission_250.pdf

Tsunami Recovery Impact Assessment and Monitoring System (TRIAMS)

The Tsunami Recovery Impact Assessment and Monitoring System (TRIAMS) was design to sidestep obstacles to planning and coordination by improving **government monitoring** of the **recovery** by focusing on limited agreed recovery outputs and outcomes. Since 2006, Indonesia, Sri Lanka, Maldives and Thailand have been using TRIAMS to help manage and track the recovery initiatives after the earthquake and tsunami in the **Indian Ocean in 2004**.

TRIAMS uses existing routine and survey sources for **quantitative** data, but **triangulates** by using the **perspectives** of beneficiary to better understand how affected people view the quality and relevance of the recovery assistance.

LIST: SET OF OUTCOME INDICATORS OF TRIAMS*

% of children below 5 who are underweight	Vital needs	Outcome
% of children below 5 who are wasting (moderate and severe)	Vital needs	Outcome
% of children below 5 who are stunting (moderate and severe)	Vital needs	Outcome
% of low birth weight newborns	Vital needs	Outcome
% of children under 5 who have experienced a diarrhoea episode during the previous 2 weeks	Vital needs	Outcome
% of overall population living in durable and safe housing	Vital needs	Outcome
% of population issued with land certificates that have changed name or collateralized in past year (country specific)	Vital needs	Outcome
% of households without home ownership	Vital needs	Outcome
net primary school enrolment ratio	Basic Social Services	Outcome
Primary school drop-out rate	Basic Social Services	Outcome
% of births attended by a skilled birth attendant	Basic Social Services	Outcome
adequate antenatal coverage (at least 4 visits during a pregnancy)	Basic Social Services	Outcome
% of local administration offices fully functioning	Infrastructure	Outcome
volume of trade (MT) through ports	Infrastructure	Outcome
# passengers through ports	Infrastructure	Outcome
% of population earning below national poverty line	Livelihoods	Outcome
average household income by gender	Livelihoods	Outcome
labour force participation rate by gender	Livelihoods	Outcome
% of households that have regained their pre-crisis livelihoods, by gender	Livelihoods	Outcome
crop and cash crop agricultural production	Livelihoods	Outcome

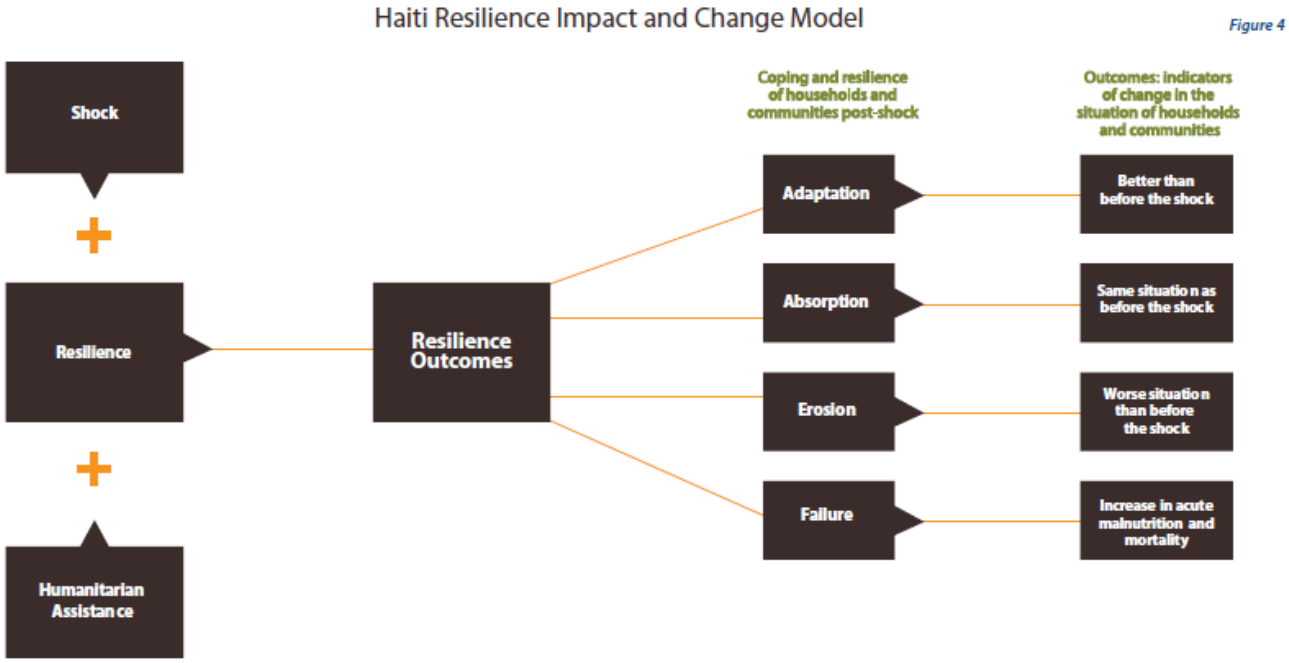
*28 output indicators and one impact indicator are not shown here, but are part of the indicator framework

Key resources:

- Tsunami Recovery Impact Assessment and Monitoring System – TRIAMS, Lessons learned in post-crisis recovery monitoring, UNDP/WHO/IFRCRC 2009, www.who.int/hac/crises/international/asia_tsunami/triams/triams_report_3.pdf

DRLA/UEH Haiti Evaluation Resilience Framework

The DRLA/UEH Evaluation Resilience Framework measures the **relationship between a shock, humanitarian assistance and resilience**. It was designed for a large scale evaluation of humanitarian assistance in the wake of the **Haiti** earthquake in 2010. The framework was put together by the Disaster Resilience Leadership Academy (DRLA) of Tulane University and the State University of Haiti (UEH).



The model involves measuring **seven resilience dimensions**: wealth, debt and credit, coping behaviours, human capital, protection and security, community networks, and psychosocial status.

By combining multiple relevant indicators, the evaluation calculated seven **quantitative composite scores**, one for each dimension. The results were triangulated with **qualitative tools** (e.g. focus groups)

Key resources:

- Tulane University 2011, Haiti Humanitarian Assistance Evaluation, From a Resilience Perspective, Disaster Resilience Leadership Academy, www.drlatulane.org/groups/haiti-humanitarian-aid-evaluation/final-report/english-documents/UEH%20Tulane%20DRLA%20Haiti%20Humanitarian%20Aid%20Evaluation%20ENGLISH%20May%202012.pdf/at_download/file

Indonesia Disaster Recovery Index (DRI)

Indonesia's Disaster Recovery Index (DRI) measures the progress of **recovery** and **resilience** in communities affected by the Mount Merapi eruption in 2010 and Lahar floods in 2011. The index utilizes **22 variables** to determine how communities are recovering from the volcanic eruption in terms of restoring infrastructure, housing, livelihoods, and social structures, among other things.

The index uses data collected through **surveys** of ca. 1,230 households that were affected and which have since received rehabilitation and reconstruction assistance. The household survey uses long term data to compare the situation in a community *before* a disaster to *after* the disaster and following the *implementation* of rehabilitation and reconstruction programmes.

By gathering data over a period of time, the survey can be used to measure the extent to which affected community members have recovered. The household survey also measures **community resilience**, which is particularly important since Merapi is a permanent hazard.

Key resources:

- Launching of the world's first disaster recovery index, UNDP, press release, 27.11.2013, www.ly.undp.org/content/indonesia/en/home/presscenter/pressreleases/2013/11/27/launching-of-the-world-s-first-disaster-recovery-index/
- Merapi Longitudinal Study, UNDP, app.box.com/s/g6wce02auyci6v1e1366

FAO Resilience Tool

The FAO resilience framework looks at the **root causes of household vulnerability** instead of trying to predict how well households will cope with future crises or disasters. It also considers how household food security links to the entire **food system**.

Factors that make households resilient to food security shocks and stresses include:

- income and access to food;
- assets such as land and livestock;
- social safety nets such as food assistance and social security;
- access to basic services such as water, health care, electricity, etc.;
- households' adaptive capacity which is linked to education and diversity of income sources; and
- the stability of all these factors over time.

These factors are combined into an index which gives an **overall quantitative 'resilience score'**. The score shows where investments need to be made to further build resilience. By using this quantitative approach, decision makers can objectively target their actions and measure their results over time.

The resilience tool uses **data available** in national household budget surveys such as the Living Standard Measurement Surveys or Household Income and Expenditure Surveys.

Key resources:

- FAO/EU, *no date*, Measuring Resilience: A Concept Note on the Resilience Tool, , www.fao.org/docrep/013/al920e/al920e00.pdf
- Alinovi/Mane/Romano 2009, Measuring household resilience to food insecurity: application to Palestinian households, working paper, January 2009, www.foodsec.org/fileadmin/user_upload/eufao-fsi4dm/docs/resilience_wp.pdf

Common Indicators for Each Component of the Resilience Model

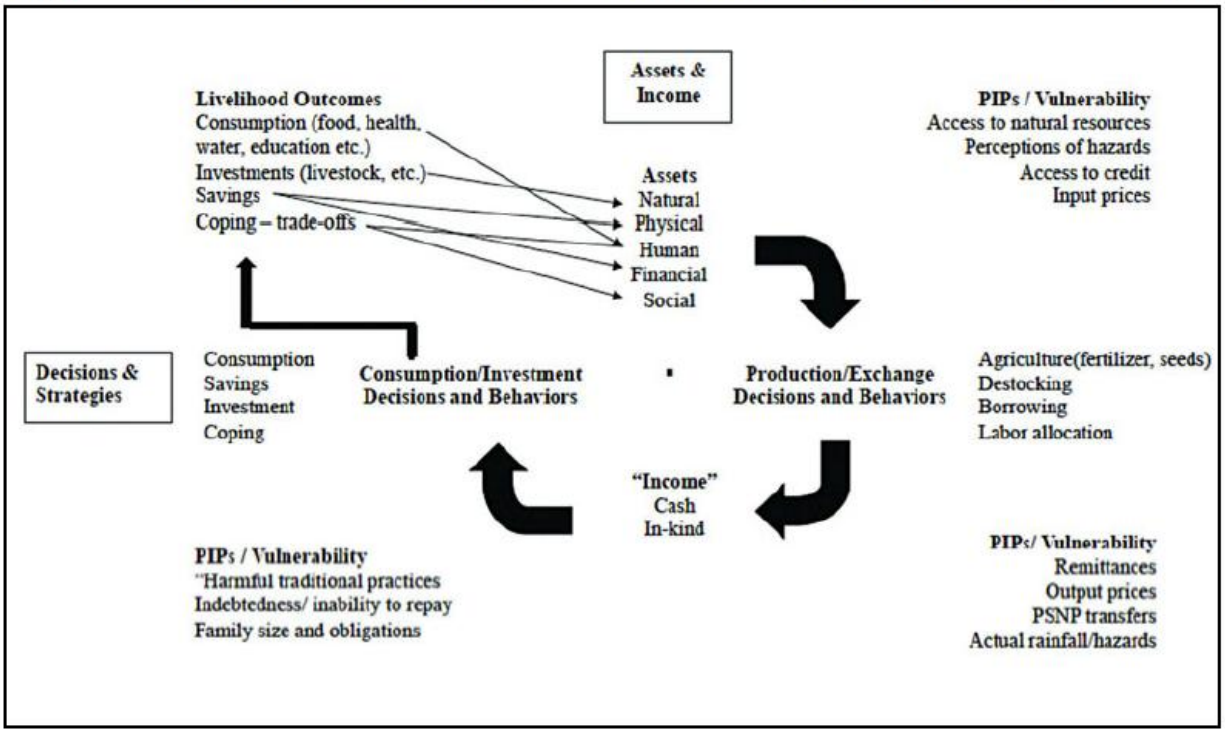
Component	Indicators
Income and Food Access	• Average per person daily income (local currency/person/day) • Average per person daily expenditure (local currency / person/day) • Household food insecurity access score • Dietary diversity and food frequency score • Dietary energy consumption (kcal/person/day)
Access to Basic Services	• Physical access to health services (ordinal, 1 to 3) • Quality score of health services • Quality of educational system (ordinal, 1 to 6) • Perception of security (ordinal, 1 to 4) • Mobility and transport constraints (ordinal, 1 to 3) • Water, electricity and phone networks (count)
Social Safety Nets	• Amount of cash and in-kind assistance (local currency/ person/day) • Quality evaluation of assistance (ordinal, 1 to 4) • Job assistance (binary yes/no response) • Frequency of assistance (number of times assistance was received in the last six months) • Overall opinion of targeting (assistance targeted to the needy; to some who are not needy; or without distinction)
Assets	• Housing (number of rooms owned) • Durable index (Principal Component Analysis on list of items: TV, Car, etc...) • Tropical Livestock Unit (TLU) equivalent to 250 KG; • Land owned (in hectares)
Adaptive Capacity	• Diversity of income sources (count, 0 to 6) • Educational level (household average) • Employment ratio (ratio, number of employed divided by household size) • Available coping strategies (count, 0 to 18) • Food consumption ratio (Share of food expenditure divided by total expenditure)
Stability	• Number of household members that have lost their job (count) • Income change (ordinal; increased, the same, decreased) • Expenditure change (ordinal; increased, the same, decreased) • Capacity to maintain stability in the future (ordinal, 1 to 5) • Safety net dependency (share of transfers on the total income) • Education system stability (ordinal; quality increased, the same, decreased)

Livelihoods Change Over Time (LCOT)

The **Livelihoods Change Over Time (LCOT) survey** is the basis of this resilience measurement. The survey collects panel data twice a year, in the postharvest period and during the peak of the hunger season, from a sample of 300 households in two locations. Since 2009, a team from Tufts University has been studying livelihoods change over time in Northern Ethiopia, focusing specifically on Eastern and Southeastern Tigray. The research objective is to understand the determinants of food security in a relatively risk-prone context.

The LCOT approach captures both **static livelihood outcomes** (e.g. food security, health status, education level) and more complex outcomes based on **dynamic interactions** between livelihood strategies, policies and programmes.

Figure 4. A detailed "Livelihoods Cycle" framework, adapted for Tigray, Ethiopia



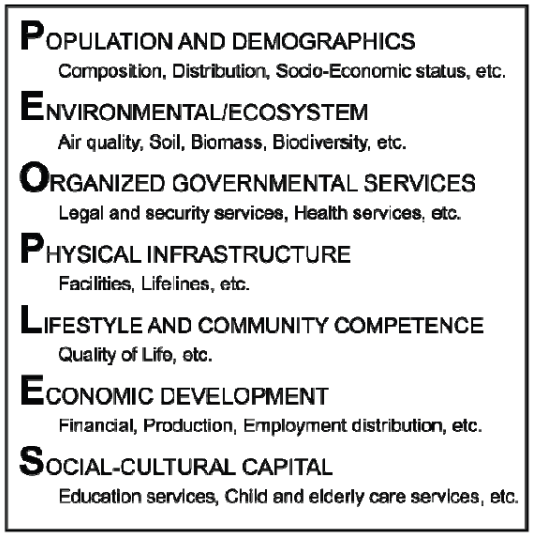
Key resources:

Maxwell/Vaitla/Tesfay/Abadi (2013), Resilience, Food Security Dynamics, and Poverty Traps in Northern Ethiopia: Analysis of a Biannual Panel Dataset, 2011–2013, Feinstein International Centre, October 2013, reliefweb.int/sites/reliefweb.int/files/resources/Ethiopia%20Resilience-Food-Security-Dynamics.pdf

PEOPLES Resilience Framework

The PEOPLES resilience framework aims at **defining and measuring disaster resilience for a community at various scales**. The framework attempts to address simultaneously the assets of the community and their functionality at various geographic and temporal scales. The framework builds upon and extends the MCEER R4 framework.

This resilience framework identifies **seven dimensions** that characterize community functionality (represented by the acronym PEOPLES): ´



The proposed framework provides a basis for developing **quantitative and qualitative models** that measure continuously the functionality and resilience of communities against extreme events or disasters in any or a combination of the above-mentioned dimensions. It includes the definition of sub-systems for each of the seven dimensions and some proposals for **potential indicators** to measure the functionality of these sub-systems.

The framework also foresees the aggregation of these potential indicators into **community resilience indices for the specific dimension** as well as an overall **community resilience index**.

Key resources:

- Renschler, Frazer, Arendt, Cimellaro, Reinhorn, Bruneau (2010), Framework for Defining and Measuring Resilience at the Community Scale: The PEOPLES Resilience Framework, , Technical Report MCEER-10-0006, October 8, 2010, mceer.buffalo.edu/pdf/report/10-0006.pdf

Community-Based Resilience Analysis (CoBRA)

The Community Based Resilience Analysis (CoBRA) is a **conceptual framework and methodology to measure resilience**. It was commissioned by **UNDP's Drylands Development Centre** in mid-2013**.**

The measurement framework foresees both **universal** as well as **contextual** indicators of resilience. To define a universal threshold for resilience based on food and basic needs, the approach uses the **Household Economy Approach** (HEA) **Response Thresholds**. To measure factors that build resilience, the analysis distinguished between five categories: physical, human, financial, natural and social.

Category	Definition	Examples	Potential Indicators	
Physical	The basic infrastructure (roads, railways, telecommunications) that people use to function more productively.	• Infrastructure – roads, water, electricity, telecoms • Access to new technologies / equipment • Land security / ownership	***Capital*** • Access to all weather roads • % households with electricity supply	***Capacity*** • % households with year round access to clean water • Water storage / reserve capabilities • Crop storage / reserve capacity
Human	The sum of skills, knowledge, labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood outcomes.	• Educational and skill levels of household members • Food security of household • Health and nutritional status of household members	***Capital*** • % households requiring formal food/cash assistance • % global and severe acute malnutrition rates • Gross / net enrolment rates	***Capacity*** • # Households members with secondary education or higher • # Household members economically active
Financial	The cash that enables people to adopt different livelihood strategies. This can be in the form of savings, or a regular source of income such as a pension or remittance. The inputs that support livelihoods, as well as the producer goods (tools, equipment, services) that contribute to the ability to increase financial capital.	• Income reliability and growth • Opportunities for employment and trade • Productivity of livelihood • Price and income variations • Functioning markets • Risk financing / insurance • Assets owned and goods produced – livestock/crop /stock • Access to financial services	Capital • Income level • % of households with secure access to land for livelihood purposes • Livestock numbers and value • Crop production / value	***Capacity*** • # household sources of earned income • Access to functioning markets • Access to saving and credit facilities • Access to agric / livestock extension services
Natural	The natural resources (land, forests, water) and associated services (e.g. erosion protection, storm protection) upon which resource-based activities (e.g. farming, fishing etc.) depend.	• Access to and quality of natural resources – land / rangeland / forests, water, soil • Sustainable management and regulation of natural resources • Carrying capacity – human and animal populations	***Capital*** • Extent of natural tree cover • Households undertaking reforestation activities • # functional NRM/ rangeland management committees	***Capacity*** • % time quality pasture available • Quality of rangeland management • Rate of deforestation

Social	Access to and participation in networks, groups, formal and informal institutions. Peace and security.	• Local kinship support networks
		• Number, scale and functionality of community organisations / governance structures and self-help groups
		• Participation in the above groups
		• Community ability to plan, mobilise resources and implement;
		  ○ Conflict reduction
		  ○ Improved services
		  ○ Natural resource management
		• Fair and transparent access to resources
		• Leadership role of women
			Capital
			• # functioning local structures / committees
			• % of households with woman and marginalized groups involved in local planning processes
				Capacity
				• Quality of leaders /institutions (fair, responsive, non-corrupt)
				• % population living in peace and security
				• % year there are no incidences of conflict / insecurity
				• Community resources raised to build resilience

Key resources:

- UNDP Drylands Development Centre 2013, Community Based Resilience Analysis (CoBRA): Conceptual Framework and Methodology, version May 17, 2013, www.seachangecop.org/sites/default/files/documents/2013%2004%20UNDP%20CoBRA%20Conceptual%20Framework%20and%20Methodology.pdf

Minimum characteristics of the Nepal Risk Reduction Consortium

The Nepal Risk Reduction Consortium has developed **9 minimum characteristics of disaster-resilient communities in Nepal**. The characteristics serve as minimum component in community based disaster risk reduction projects, but also to track progress towards increasing disaster resiliency at community level. The minimum characteristics are:

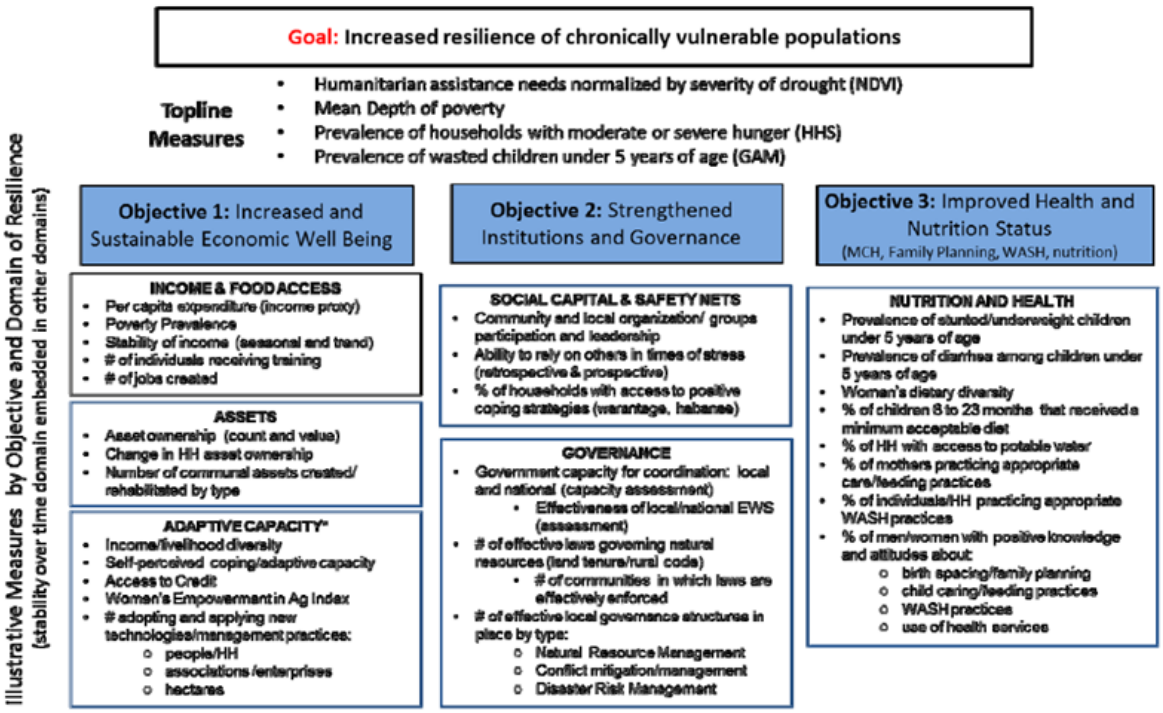
The indicators are examples and recommendations. They are nearly all (with the exception of two) at the **output** level. The Nepal Risk Reduction Consortium is currently developing **outcome** and **impact** indicators.

Key resources:

- Flagship 4, 9 Minimum Characteristics, flagship4.nrrc.org.np/minimum-characteristics
- Flagship 4 Handbook, Nepal's 9 Minimum Characteristics of a Disaster Resilient Community, Nepal Risk Reduction Consortium, July 2013, http://flagship4.nrrc.org.np/document/flagship-4-handbook-english

USAID Resilience Domain Framework

USAID has adapted a **FAO resilience domain framework** and identified a number of potential indicators under each domain. This framework makes use of **existing indicators** and data already collected in standard FFP/FTF baseline surveys, adding in a limited set of additional measures.



As part of this framework, USAID is piloting a **resilience module in Kenya and Ethiopia** that focuses on measuring resilience capacities. The module uses a **survey** on self-perception and includes retrospective as well as prospective questions.

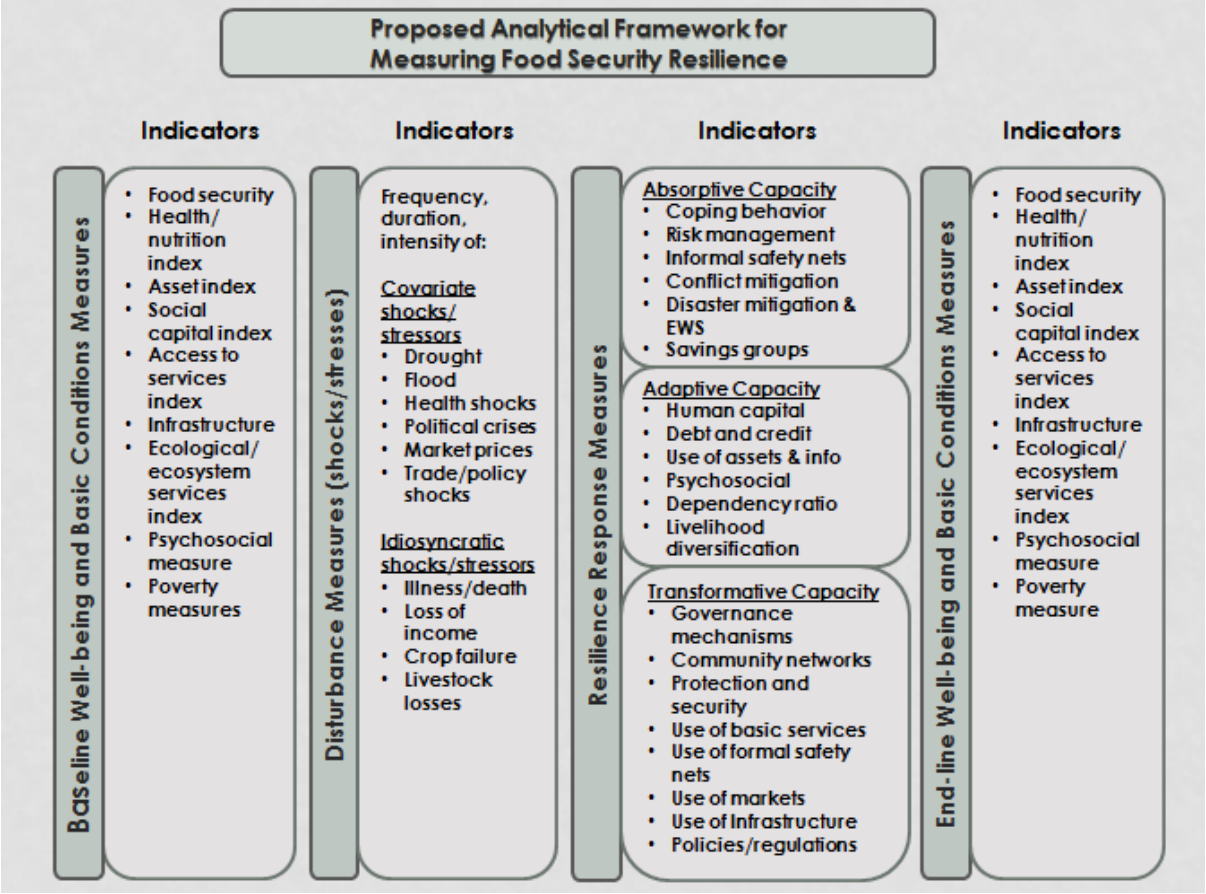
Key resources:

- USAID (no date), The Resilience Agenda: Measuring Resilience in USAID, www.usaid.gov/sites/default/files/documents/1866/Technical%20Note_Measuring%20Resilience%20in%20USAID_June%202013.pdf

Expert Consultation on Resilience Measurement for Food Security

The proposed measures for estimating **food security resilience** are the result of a three-day expert consultation on resilience measurement held in Rome in February 2013. The consultation was organized by the FAO and the WFP.

The proposed measurement consists of **four set of indicators** for a) baseline well-being and basic conditions, b) disturbances, c) response, and d) end-line well-being:



Source: Frankenberger/Nelson/TANGO International 2013

Work on the proposed measurement continues under the umbrella of a newly constitutional **Food Security Information Network** (FSIN) (www.fsnnetwork.org)

Key resources:

- Frankenberger/Nelson/TANGO International (2013), Summary of the Expert Consultation on Resilience Measurement for Food Security, FAO/WFP, www.seachangecop.org/sites/default/files/documents/2013%2002%20FAO%26WFP%20-%20Resilience%20Measurement%20for%20Food%20Security-1.pdf

ODI Disaster Risk Management Indicators

The **Overseas Development Institute** proposes a comprehensive set of indicators to be part of the post-2015 development goals. The indicators cover **all levels of the result chain** (inputs, outputs, outcome, impact) and **geographic scales** (individual, household, community, sub-national, national, international).

Table: Proposed indicators at impact, outcome and output level*

	International	National	Sub-National (e.g., city level)	Local (individual, household and community levels).*
Impact				• Number of people entering poverty due to a disaster
Outcome	• Disaster losses: economic and human, direct and indirect (including secondary/flow losses)	• Disaster losses: economic and human, direct and indirect (including secondary/flow losses). • Direct economic losses as percentage of GDP • Number of houses damaged / Number of houses damaged per million people per year • Annual spending on humanitarian relief	• Disaster losses: economic and human, direct and indirect (including secondary/flow losses)	• Disaster losses: economic and human, direct and indirect (including secondary/flow losses). • % loss of agricultural output due to natural hazards • % of household/firm assets lost due to natural hazards
Output	• Existence of 'effective' regional risk pools	• Effectiveness/ coverage of insurance sector • Proportion of the population living in areas that are exposed to natural hazards • Proportion of the population living at an elevation below 5m above sea level • Proportion of GDP in exposed areas • % of population with access to formal or informal risk transfer/sharing (including insurance and social safety nets)	• % of area complying with no development or no construction by-laws • % of buildings complying with building standards aimed at disaster resilience	• Access to formal and informal risk-transfer and – sharing (access and depth) • Access to and depth of insurance for critical infrastructure, industry, housing social and productive sectors • % with the ability to access disaster risk information to enable informed choices • % with access to modern early warning systems • % of firms adopting standards for business continuity and risk management

** does not include proposed input indicators*

Source: Mitchell T./Jones/Lovell/Comba (2013), p. 100

Key resources:

- Mitchell T./Jones/Lovell/Comba (2013) (eds), Disaster Risk Management in Post-2015 Development Goals: potential targets and indicators, Overseas Development Institute, www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8354.pdf

Basket of indicators of economic resilience

Two authors from the Grantham Research Institute on Climate Change and the Environment from the London School of Economics and Political Science propose a set of targets and indicators to be part of a **post-2015 development framework**. The measurements are based on the concept of '**economic resilience'** as a crucial component of development and poverty alleviation.

	Indicator type	Proposed indicator
I	Input-based, national	National DRR and resilience plans adopted and budgets earmarked in national development plans, and integrated into national, sectoral and local programmes (Mitchell, 2012)
II	Outcome-based, national	Fraction of GDP allocated to DRR and preparedness (Matyas and Pelling, 2012)
III	Outcome- based, national	Annual spending on humanitarian relief and reconstruction financing* (IRDR, 2012; Mitchell, 2012)
IV	Outcome-based, sectoral	% loss of agricultural output
V	Output-based, multi-scale	% of critical infrastructure (schools, hospitals, utilities) at risk from natural hazards (IRDR, 2012)
VI	Output-based, multi-scale	% of fixed assets (buildings and infrastructure) at risk from natural hazards
V	Output-based, multi-scale	% of population in areas that are at risk from natural hazards
VI	Output-based, local	% of population with ability to access disaster risk information and EWSs
VII	Output-based, local	% of firms adopting recognised standards for business continuity and risk management
VIII	Output-based, local	% of population with access to formal or informal risk transfer/ sharing (Matyas and Pelling, 2012) (including insurance and social safety nets)
XI	Impact-based, local	# of people entering poverty owing to a disaster
X	Outcome-based, local	Total economic losses per unit output by sector and region

Source: Ranger/Surminski (2013), p. 22

Key resources:

- Ranger/Surminski (2013), Disaster and their economic impacts, in: Mitchell T./Jones/Lovell/Comba (eds), Disaster Risk Management in Post-2015 Development Goals: potential targets and indicators, Overseas Development Institute 2013, www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8354.pdf

Resilience cost approach

To overcome some of the concerns and limitations of resilience measurement using a set of characteristics, this **new approach** puts **'costs of resilience'** at the centre. Costs of resilience refer to the different ex-ante and ex-post investments, losses, sacrifices, and costs that people have to undertake at individual and collective levels to 'go through' a shock or an adverse event.

Table 1 Categories of costs* associated with resilience

Categories	Description
Economic– financial	investments in infrastructure (ex ante), income loss – asset loss (shock) – reconstruction (ex post), asset depletion (coping) – debt contracting (coping)
Ecological	resource mining, environmental degradation (coping)
Social	[relational wellbeing] : social relation degradation, conflicts (recovery)
Psychological	[subjective wellbeing]: stress (shock), adaptive preference (recovery)
Nutritional/food security	(impact of shock) Coping strategy Indicators

Source: Béné (2013a, p. 15)

The assumption is that quantifying these resilience costs gives an **indication of the level of resilience of a system** (or component of that system). The lower the resilience costs, the more resilient the system is (to a given shock).

Key resources

- Béné (2013), Towards a Quantifiable Measure of Resilience, IDS Working Paper No. 434, IDS, www.ids.ac.uk/publication/towards-a-quantifiable-measure-of-resilience

MCEER R4 Resilience Framework

The MCEER R4 Resilience Framework is a framework for **defining and measuring disaster resilience at the community scale**. It is based on the assumption that improvements in resilience are achieved through the application of **advanced technologies** and **decision tools** in both the pre- and post-extreme event context. Research seeks to obtain quantitative data on the extent to which these measures result in improvements in resilience for **infrastructure systems, hospitals, and communities**. The R4 Resilience Framework has been developed by the **Multidisciplinary Center for Earthquake Engineering Research (MCEER)** of the University of Buffalo, USA.

The MCEER R4 Resilience Framework consists of four dimensions: technical, organizational, social, economic and four domains:

- **Robustness** as the ability of systems, system elements, and other units of analysis to withstand disaster forces without significant degradation or loss of performance
- **Redundancy** as the extent to which systems, system elements, or other units are capable of satisfying functional requirements, if significant degradation or loss of functionality occurs;
- **Resourcefulness** as the ability to diagnose and prioritize problems and to initiate solutions by identifying and mobilizing material, monetary, informational, technological, and human resources; and
- **Rapidity** as the capacity to restore functionality in a timely way, containing losses and avoiding disruptions.

Resilience Property Space & Examples

Dimension/ Domain	Technical	Organizational	Social	Economic
Robustness	Newer Structures, Built to Code	Extensiveness of Emergency Operations Planning	Social Vulnerability/ Resilience Indicators	Extent of Economic Diversification
Redundancy	Capacity for Technical Substitutions, "Work-Arounds"	Alternate Sites for Managing Disaster Operations	Availability of Housing Options for Disaster Victims	Ability to Substitute, Conserve Needed Inputs
Resourceful-ness	Availability of Materials for Restoration, Repair	Capacity to Improvise, Innovate, Expand	Capacity to Address Hum-an Needs	Capacity to Improvise, Innovate
Rapidity	System Downtime, Restoration Time	Time Between Impact & Early Recovery	Time to Restore Life-line Services	Time to Regain Capacity, Lost Revenue

Source: mceer.buffalo.edu/meetings/AEI/presentations/01Bruneau-ppt.pdf

The R4 Resilience Framework has been used to analyze a number of **disasters** (see mceer.buffalo.edu/research/Resilience_Framework/). However, it appears that a general measurement framework with a set of indicators for MEERC's R4 has not been developed.

Key resources:

- Tierney/Bruneau (2007), Conceptualizing and Measuring Resilience: A Key to Disaster Loss Reduction, TR News 250: 14-17, 2007, onlinepubs.trb.org/onlinepubs/trnews/trnews250_p14-17.pdf

Network of Adaptive Capacities

The Network of Adaptive Capacities understands community resilience as a process – not as an outcome - **linking a network of adaptive capacities to adaptation after a disaster**.
The term "adaptive capacities'' refers to the fact that in this model, resilience rests on both the resources themselves and the **dynamic attributes** of those resources (robustness, redundancy, rapidity). The network also encompasses contemporary understandings of **stress, adaptation, wellness,** and **resource dynamics**. Together they provide a strategy – and in turn a measurement framework - for **disaster readiness**.

The model assumes that community resilience emerges from **four primary sets of adaptive capacities:** economic development, social capital, information and communication, community competence.

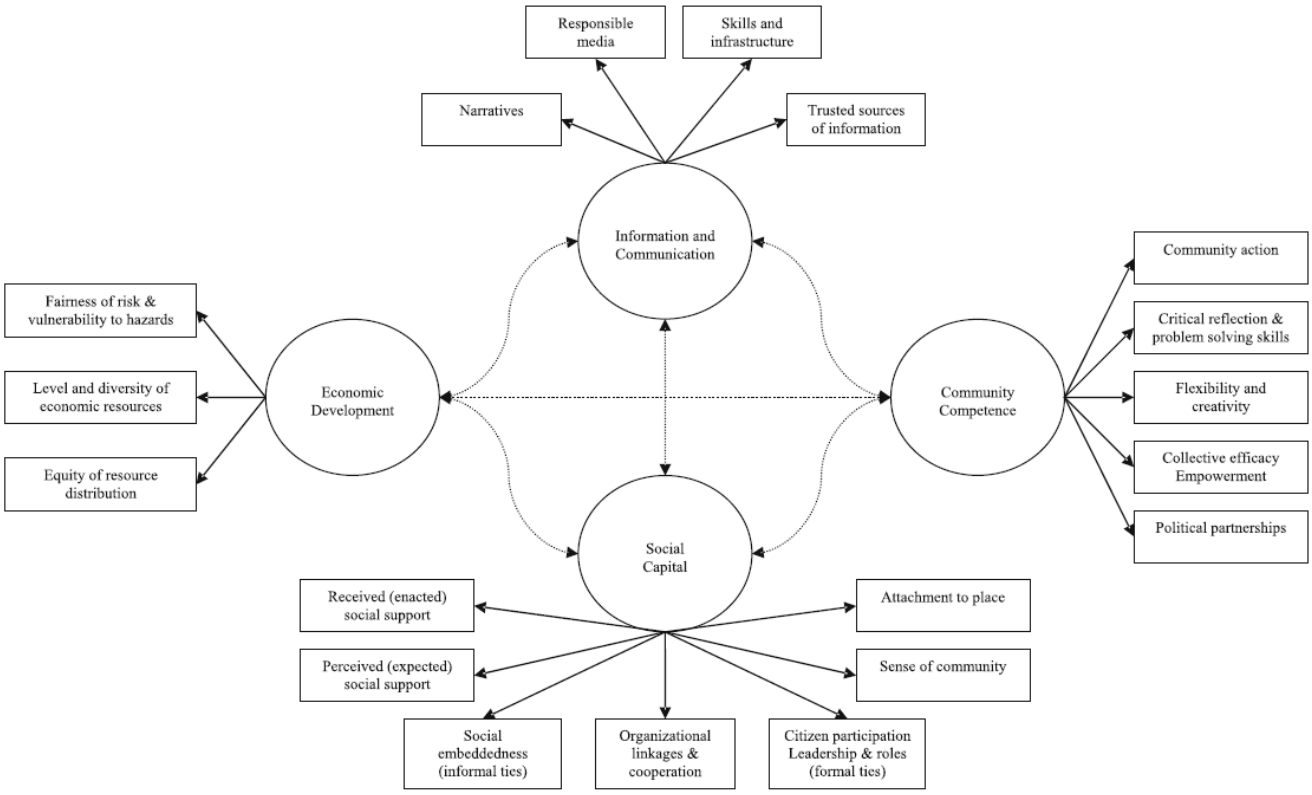


Fig. 2 Community resilience as a set of networked adaptive capacities

Key resources:

- Norries/Stevens/Pfefferbaum/Wyche/Pfefferbaum (2008), Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness , in: Am J Community Psychol (2008) 41:127–150, http://www.emergencyvolunteering.com.au/ACT/Resource%20Library/CR_metaphor_theory_capacities.pdf

- Jamil/Amul (2013), Community resilience and critical urban infrastructure: Where adaptive capacities meet vulnerabilities, in: NTS Insight no. IN13-07, December 2013, www.academia.edu/5648833/Community_resilience_and_critical_urban_infrastructure_Where_adaptive_capacities_meet_vulnerabilities

BIBLIOGRAPHY

Alinovi/Mane/Romano (2009), Measuring household resilience to food insecurity: application to Palestinian households, working paper, January 2009, www.foodsec.org/fileadmin/user_upload/eufao-fsi4dm/docs/resilience_wp.pdf

Bandura (2008), A Survey of Composite Indices Measuring Country Performance: 2008 Update, A UNDP/ODS Working Paper, Office of Development Studies, UNDP

Birkmann (2007), Risk and vulnerability indicators at different scales: Applicability, usefulness and policy implication, in: Environmental Hazards 7 (2007), 20-31

Béné (2013a), Towards a Quantifiable Measure of Resilience, IDS Working Papers no. 434, IDS

Béné (2013b), Can we actually measure resilience, blog, vulnerabilityandpoverty.blogspot.com.es/2013/10/can-we-actually-measure-resilience.html

Béné/Wood/Newsham/Davis (2013), Making the Most of Resilience, IDS In Focus Policy Briefing 32, www.ids.ac.uk/publication/making-the-most-of-resilience

Béné/Wood/Newsham/Davis 2012, Resilience: New Utopia or New Tyranny?, IDS Working Paper 405, www.ids.ac.uk/publication/resilience-new-utopia-or-new-tyranny

Burton (2012), The Development of Metrics for Community Resilience to Natural Disasters, Ph.D. Thesis, Geography College of Arts and Sciences , University of South Carolina 2012, webra.cas.sc.edu/hvri/education/docs/Chris_Burton_2012.pdf

Constas/Barrett (2013), Principles of Resilience Measurement for Food Insecurity: Metrics, Mechanisms, and Implementing Issues; paper presented at the Expert Consultation on Resilience Measurement Related to Food Security, Rome, February 19-21, 2013

Cardona (2007), Indicators of Disaster risk and Risk Management, updated 2007, Inter-American Development Bank, ipcc-wg2.gov/njlite_download.php?id=6132

Cardona/Carreño (2011), Updating the Indicators of Disaster Risk and Risk Management for the Americas , in: Journal of Integrated Disaster Risk Management, IDRiM (2011) 1(1), idrimjournal.com/index.php/idrim/article/viewFile/14/PDF

Cutter/Barnes/Berry/Burton/Evans/Tate/Webb (2008a), A place-based model for understanding community resilience to natural disasters, in: Global Environmental Change 18 (2008), 598-606, lbrr.covalentwords.com/assets/docs/33.pdf

Cutter/Barnes/Berry/Burton, Evans/Tate/Webb (2008b), Community and Regional Resilience: Perspectives from Hazards, Disasters, and Emergency Management, Hazards and Vulnerability Research Institute, Department of Geography, University of South Carolina, CARRI Research Report 1, September 2008, www.resilientus.org/wp-content/uploads/2013/03/FINAL_CUTTER_9-25-08_1223482309.pdf

Cutter (2011), Disaster Resilience: What we Know, What we Need to Know, presentation, Second Conference on Community Resiliency, Arlington, VA, 19/09/2011

Cutter/Emrich/Burton *(no date)*, Baseline Indicators for Disaster Resilient Communities, Hazards & Vulnerability Research Institute, University of South Carolina, CARRI Workshop in Broomfield, USA, July 14-15, www.resilientus.org/wp-content/uploads/2013/03/Susan_Cutter_1248296816.pdf

Cumming/Barnes/Perz/Schmink/Sieving/Southworth/Binford/Holt/Stickler/Van Holt (2005), An Exploratory Framework for the Empirical Measurement of Resilience, in: Ecosystems (2005) 8: 975-987

Downie/Chesterman/Bacou (*no date*), Technical Consortium: Measuring Resilience: Decision Analysis Tools and Member State Baseline Datasets for Impact, ILRI/CGIAR, presentation

FAO/EU (*no date*), Measuring Resilience: A Concept Note on the Resilience Tool, EC-FAO Programme on 'Linking Information and Decision Making to Improve Food Security', www.fao.org/docrep/013/al920e/al920e00.pdf

Frankenberger/Nelson (2013), Summary of the Expert Consultation on Resilience Measurement for Food Security, FAO/WFP, www.seachangecop.org/sites/default/files/documents/2013%2002%20FAO%26WFP%20-%20Resilience%20Measurement%20for%20Food%20Security-1.pdf

Frankenberger/Spangler/Nelson/Langworthy (2012), Enhancing Resilience to Food Security Shocks in Africa, Discussion Paper, TANGO International, November 2012

Irajifar/Alizedh/Sipe (*no date*), Disaster resilience measurement frameworks: sate of the art, paper submitted to the 19th CIB World Building Congress, May 2013, Queensland University of Technology, www.conference.net.au/cibwbc13/papers/cibwbc2013_submission_250.pdf

Jamil/Amul (2013), Community resilience and critical urban infrastructure: Where adaptive capacities meet vulnerabilities, in: NTS Insight no. IN13-07, December 2013, www.academia.edu/5648833/Community_resilience_and_critical_urban_infrastructure_Where_adaptive_capacities_meet_vulnerabilities

Maxwell/Vaitla/Tesfay/Abadi (2013), Resilience, Food Security Dynamics, and Poverty Traps in Northern Ethiopia: Analysis of a Biannual Panel Dataset, 2011–2013, Feinstein International Centre, October 2013, reliefweb.int/sites/reliefweb.int/files/resources/Ethiopia%20Resilience-Food-Security-Dynamics.pdf

Gall (2007), Indices of Social Vulnerability to Natural Hazards: a Coparative Evaluation, Ph.D. Thesis, Department of Geography University of South Carolina, webra.cas.sc.edu/hvri/education/docs/Melanie_Gall_2007.pdf

Gall (2013), From Social Vulnerability to Resilience: Measuring Progress towards Disaster Risk Reduction, Interdisciplinary Security Connections, UNU-EHS, No. 13/2013

Jamil/Amul (2013), Community resilience and critical urban infrastructure: Where adaptive capacities meet vulnerabilities, in: NTS Insight no. IN13-07, December 2013, www.academia.edu/5648833/Community_resilience_and_critical_urban_infrastructure_Where_adaptive_capacities_meet_vulnerabilities

Kyoto University/Metroplanado (2010), Metro Manila City Profile: Climate and Disaster Resilience, Climate and Disaster Resilience Initiative (CDRI)

Mayankga (2007), Understanding and Applying the Concept of Community Disaster Resilience: A capital-based approach, draft working paper prepared for the summer academy for social vulnerability and resilience building, July 2007, Munich/Germany

Mayankga/Peacock (2010), The Development of a Community Disaster Resilience Framework and Index, in: Peackock 2010 (eds), Advancing the Resilience of Coastal Localities: Developing, Implementing and Sustainaing the Use of Coastal Resilience Indicators: Final Report, Hazard Reduction and Recovery Center, Texas A&M University, December 2010, pp. 3-58

Mitchell A. (2013a), Risk and Resilience: From Good Idea to Good Practice: A scoping study for the Experts Group on Risk and Resilience, OECD, December 2013

Mitchell A. (2013b), Analysing and Measuring Resilience: Methodological Overview, OECD, not published, 25.11.2013

Mitchell T./Jones/Lovell/Comba (2013) (eds), Disaster Risk Management in Post-2015 Development Goals: potential targets and indicators, Overseas Development Institute, www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8354.pdf

Norries/Stevens/Pfefferbaum/Wyche/Pfefferbaum (2008), Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness , in: Am J Community Psychol (2008) 41:127–150, www.emergencyvolunteering.com.au/ACT/Resource%20Library/CR_metaphor_theory_capacities.pdf

NRRC (2013), Flagship 4 Handbook, Nepal's 9 Minimum Characteristics of a Disaster Resilient Community, Nepal Risk Reduction Consortium, July 2013, http://flagship4.nrrc.org.np/document/flagship-4-handbook-english

Ranger et. al. (2011), An assessment of the potential impact of climate change on flood risk in Mumbai, in: Climatic Change (2011) 104:139–167, www.lse.ac.uk/CATS/Publications/Publications%20PDFs/85_Ranger_AssessmentMumbai_2011.pdf

Ranger/Surminski (2013), Disaster and their economic impacts, in: Mitchell et al (eds), Disaster Risk Management in Post-2015 Development Goals: potential targets and indicators, Overseas Development Institute 2013, www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8354.pdf

Renschler/Frazer/Arendt/Cimellaro/Reinhorn/Bruneau (2010), Framework for Defining and Measuring Resilience at the Community Scale: The PEOPLES Resilience Framework, , Technical Report MCEER-10-0006, October 8, 2010, mceer.buffalo.edu/pdf/report/10-0006.pdf

Sherrieb/Norries/Galea (2010), Measuring for Community Resilience, in: Soc Indic Res (2010), 99:227-247

The Government Office for Science (2012), Foresight Reducing Risks of Future Disasters: Priorities for Decision Makers, Final Project Report, London, www.bis.gov.uk/assets/foresight/docs/reducing-risk-management/12-1289-reducing-risks-of-future-disasters-report.pdf

Tierney/Bruneau (2007), Conceptualizing and Measuring Resilience: A Key to Disaster Loss Reduction, TR News 250: 14-17, 2007, onlinepubs.trb.org/onlinepubs/trnews/trnews250_p14-17.pdf

Tulane University (2011), Haiti Humanitarian Assistance Evaluation, From a Resilience Perspective, Disaster Resilience Leadership Academy, www.drlatulane.org/groups/haiti-humanitarian-aid-evaluation/final-report/english-documents/UEH%20Tulane%20DRLA%20Haiti%20Humanitarian%20Aid%20Evaluation%20ENGLISH%20May%202012.pdf/at_download/file

UNDP (2013), Community Based Resilience Analysis (CoBRA): Conceptual Framework and Methodology, UNDP Drylands Development Centre, version May 17, 2013, www.seachangecop.org/sites/default/files/documents/2013%2004%20UNDP%20CoBRA%20Conceptual%20Framework%20and%20Methodology.pdf

UNDP/WHO/IFRCRC (2009), Tsunami Recovery Impact Assessment and Monitoring System – TRIAMS, Lessons learned in post-crisis recovery monitoring, 2009, www.who.int/hac/crises/international/asia_tsunami/triams/triams_report_3.pdf

USAID (*no date*), The Resilience Agenda: Measuring Resilience in USAID, www.usaid.gov/sites/default/files/documents/1866/Technical%20Note_Measuring%20Resilience%20in%20USAID_June%202013.pdf

Weijer (2013), Resilience: a Trojan horse for a new way of thinking? ecdpm discussion paper no. 139, January 139, European Centre for Development Policy Management