Cascade effects triggered by natural disasters

The 1811-12 New-Madrid earthquakes and the failure of Mississippi banks
\textit{(Devens, woodcut, 1877)}

The most recent: the eruption of the volcano Eyjafjallajökull, the Tōhoku earthquake of 2011, Hurricane Sandy
Multi-hazard vs. Cascade Effects

Multi-hazard events are commonly perceived as ‘very-low’ probability threats.

Cascade Effects (even when triggered by a single hazard) are ‘huge-consequence’ when Critical Infrastructures are disrupted.

Exposure to Cascade Effects is then a likely disruption of Resilience.

By definition, Critical Infrastructure may amplify both Asset and Vulnerability risk factors.
Risk from Cascade Effects is expected to grow with:
- increased dependency on critical infrastructure (i.e. increase of criticality)
- increased (or unexpected) vulnerability of critical infrastructure

Risk from Cascade Effects cannot predicted with the traditional ‘decomposition’* approach

*(Hazard-Exposure-Vulnerability multiplication through simple maps overlay)

Korkali et al., 2017, Nature
Shift of paradigm in risk prediction/assessment:

From scenarios based on hazard (and what it may affect) to scenarios based on failure escalation from critical nodes (and what are they vulnerable to)
Example of cascade (City of Firenze): flood hazard and urban water supply

- Flood from the Arno river
  - Power failure in the pumping station of the water treatment plant
  - Dispersion from pollution hotspots
- Earth slips
- Water pipeline breaches
- Loss of pressure in pipe network
- Contamination of water distribution system
- Main water treatment plant
The potential spread of pollutants due to floods is an aspect that has been rarely examined with a risk-based approach. The aim is to estimate potential pollution risks related to flood events affecting environmental pollution hotspots (EPHs). Risk is defined as the combination of:

1. Flood hazard
2. Exposure of EPHs
3. Pollution potential + environmental susceptibility
Example: Contaminated sites (CSs) at risk

Firenze urban district

Arrighi, Masi, Iannelli: Flood risk assessment of Environmental Pollution Hotspots
Pressure distribution in the water supply network in case of power failure at main pumping station (likely in case of flooding)

0-pressure nodes in flooded areas, potential contaminant intrusion

Arrighi, Tarani, Vicario and Castelli: Flood Impacts on a Water Distribution Network
A pipe is considered to be contaminated if at any point in time the head inside the pipe is lower than the flood water head outside or below zero.)
Assessing the Current Landscape 1: scientific advances in the identification and assessment of disaster risk
Verticals:

• Advancements in prediction capabilities
  • Bayesian approaches based on precursors (e.g. earthquake, floods)
• Climate change and extreme events
  • ... the very extreme ones
Horizontals:

• Big Data Analytics
• Multi-hazard
  • *Simultaneous and cascading*
• Cascade effects
  • *NaTech, Critical Infrastructures*
Spinning:
• Reconciling uncertain prediction with utilitarian decision
  • *Dressing probabilistic forecast with real-time impact scenarios*
• Resilience through education
  • *Augmented reality, rare events and familiar environment*
• Measuring science impact through Sendai indicators
Fausto Guzzetti
Istituto di Ricerca per la Protezione Idrogeologica
Consiglio Nazionale delle Ricerche
INDEX

• Keywords
• Prediction
• Open issues
• Conclusions
“Prediction is very difficult, especially about the future”

Niels Bohr
Physicist and 1922 Nobel laureate
Which hazard?

- sinkhole
- hurricane
- meteorite impact
- flood
- avalanche
- erosion
- drought
- forest fire
- liquefaction
- frost
- volcanic eruption
- earthquake
- lightning
- subsidence
- lahar
- snow
- rainfall
- tsunami
- glacial lake outburst flood
- freak wave
- flash flood
- subsidence
- sinkhole
- rainfall
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Disaster, Risk, Resilience.

Hazard, Vulnerability.

Prediction.
Prediction [noun]  
/prɪˈdɪkʃ(ə)n/  
A thing predicted; a forecast.  
The action of predicting something.  

https://en.oxforddictionaries.com/definition/prediction
TO PREDICT

Predict [verb]
/prɪˈdɪkt/

Say or estimate that a specified thing will happen in the future, or will be a consequence of something.

from the Latin verb praedicere, prae- [beforehand] + dicere [say]

https://en.oxforddictionaries.com/definition/predict
**Forecast**

**Forecast** [noun]

/ˈfɔːkɑːst/

A **calculation** or **estimate** of **future events**, especially coming weather or a financial trend.

[https://en.oxforddictionaries.com/definition/forecast](https://en.oxforddictionaries.com/definition/forecast)
TO FORECAST

Forecast [verb]

/ˈfɔːkɑːst/

Predict or estimate a future event or trend.

https://en.oxforddictionaries.com/definition/forecast
PREDICT VS. FORECAST

In some discipline, a difference exists between prediction [to predict] and forecast [to forecast].
LINGUISTICS

In some language [e.g., Italian], a single word exists for prediction and forecast.

Language determines or influences our thoughts and decisions.
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ANTICIPATION OF FUTURE EVENTS

“The most direct … problem which our conscious knowledge of nature should enable us to solve is the anticipation of future events, so that we may arrange our present affairs in accordance with such anticipation.”

Heinrich Rudolf Hertz, Physicist
“As the basis for the solution of this problem we always make use of our knowledge of events which have already occurred, obtained by chance observation of by pre-arranged experiment.”

Heinrich Rudolf Hertz, Physicist
UNIFORMITARIANISM

Geological phenomena that operate today have operated, with the same intensity, in the past.

The present is the key to the past.

The past is the key to the future.

James Hutton, Geologist
Predicting phenomena

Phenomena characterized by high predictability, and low randomness.

Phenomena characterized by low predictability, and high randomness.

Nassim Nicholas Taleb (2004)
PREDICTING (NATURAL) PHENOMENA

Prediction of low randomness (natural) phenomena can be based on the analysis of past events.

\[ T = 2\pi \sqrt{\frac{L}{g}} \]

- \( T \), period
- \( L \), length
- \( g \), gravitational acceleration
PREDICTING (NATURAL) PHENOMENA

By AllenMcC. (Own work)
CC BY-SA 3.0 http://creativecommons.org/licenses/by-sa/3.0
via Wikimedia Commons

By Gonfer (Gonfer)
CC BY-SA 3.0 http://creativecommons.org/licenses/by-sa/3.0
via Wikimedia Commons
PREDICTING (NATURAL) PHENOMENA

For phenomena characterized by high randomness, prediction can be misled by the analysis of past events.

By: Jeff Schmaltz, NASA
PREDICTING (ECONOMIC) PHENOMENA

Nassim Nicholas Taleb (2004)
Predicting (natural) phenomena

Günter Blöschl & Alberto Montanari (2010)
Present-day measures and observations [...] may **add uncertainty** in the prediction of future trends.
NOTHING NEW

“It is easier to study the motion of infinitely distant celestial bodies than that of a stream flowing at our feet.”

Galileo Galilei, Scientist
Predicting what?

*Where* or *when* it may occur.

*Where* or *when* it will occur.

*How intense* or *destructive* it can, or will be.
PREDICTING WHAT?

Tomorrow there will be an earthquake ✓

Tomorrow there will be an earthquake in Italy ✓

1969 earthquakes in 2015 in Italy

By: National Earthquake Centre, INGV
Prediction vs. Useful Prediction

Within the next 7 days [when] there will be an earthquake of magnitude 6 or larger [how large], at a depth of 10 km, in XYZ [where].

This is a useful prediction, which we are not able to do today (unfortunately).
USEFUL TO WHOM?

Something useful to a **scientists** may not be useful to a **decision maker** or a **citizen**, and vice versa.
**WHITE & BLACK SWANS?**

Fausto **Guzzetti** (2007)  
Nassim Nicholas **Taleb** (2004)
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RISK EQUATION

\[ R = H \times V \times E \]

\[ H = M \times T \times S \]

\[ R = M \times T \times S \times V \times E \]
Risk Equation

\[ P(r) = R(m) \times P(t) \times S(s) \times P(vE) \times P(e) \]

Is this probabilistic framework too complex?

Is there an alternative framework?
## Hazards are not Equal

<table>
<thead>
<tr>
<th>Risk</th>
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<th>Vulnerability</th>
<th>Exposure</th>
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</table>

- 🌑 poor
- 🌕 sufficient
- 🌘 good
Vulnerability & Exposure

Not known sufficiently, for most hazards.

Change in time and space.
A QUESTION OF SCALE

Our ability to predict a hazard depends on the scale of the prediction.
MODEL VALIDATION & UNCERTAINTY

Very **advanced** in some communities, **poorly performed** in other communities.

Model validation is often **too optimistic**.
Model validation & Uncertainty

Standards do not exist for all hazards / communities.

Numerical models are often not open.

Data not available for independent validation.
Scientists or Fortune Tellers?

Albert Einstein
Physicist and Nobel laureate, 1922

Tiresia
Greek fortune teller
MULTIPLE HAZARDS VS. HAZARD CHAINS

Multiple hazards: two of more hazards in the same area, at the same time or at different times.

Hazard chain: A first hazard triggers a second hazard, that triggers a third hazard … in the same general area.
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Are we on the right track?

Good ability to predict some hazard; insufficient ability to predict other hazards.

Better at predicting where than when or how large a hazard is expected.

Poor ability to predict complex (multiple, chained) events.
ARE WE ON THE RIGHT TRACK?

Is the framework used to ascertain the risk posed by a natural hazard adequate for risk reduction and to improve resilience?
ARE WE ON THE RIGHT TRACK?

Improve risk **communication** to rise awareness.

**Informed** communities are **safer** and more **resilient** communities.
ON PREDICTION

“Trying to predict the future is like trying to drive down a country road at night with no lights while looking out the back window”

Peter F. Drucker
Economist and writer
THANK YOU!

Fausto.Guzzetti@irpi.cnr.it
WORDS ARE IMPORTANT

“The pen is mightier than the sword.”

Edward **Bulwer-Lytton**
English author, novelist, poet
**Black Swan Theory**

**The Black Swan Theory**

- Sometimes I calculate the probability of some improbable events...
  - This has a chance of 0.00872% of happening...

- My predictions are pretty accurate...
  - As expected!!! It didn't happen...

- But I may miscalculate...
  - Based on geography, time, causality and weather... There's only a 0.000000000001% chance of meeting her here!

- And be surprised...
  - Hi!

**By the Black Swan Event**

© Otaviodiniz
Risk Equation

\[ R = M \times T \times S \times V \times E \]

Is this probabilistic framework too complex?

Is there an alternative framework?
E-INFRASTRUCTURE AND DATA MANAGEMENT CRA: CALL FOR DEMONSTRATORS

Stefano Nativi
(CNR-IIA)
CALL ON

DEMONSTRATORS FOR ACCELERATING TRANS-NATIONAL DATA USE AND LEVERAGING BELMONT DATA PRINCIPLES IN THE CONTEXT OF INTERDISCIPLINARY GLOBAL CHANGE RESEARCH CHALLENGES.
OBJECTIVES

• ADDRESS WELL-IDENTIFIED, RESEARCH-DRIVEN TECHNOLOGICAL AND ORGANISATIONAL BARRIERS

• DELIVER AND DEMONSTRATE EXTENDED AND INCLUSIVE FUNCTIONALITY FOR ACCELERATING THE FULL-PATH OF DATA USE, FROM CAPTURE AND MANAGEMENT TO ANALYSIS, MODELING, AND PUBLICATION

• FACILITATE THE PROCESS OF OBTAINING RESULTS FROM RESEARCH-DERIVED DATA THAT BROADLY IMPACT RESEARCH PRACTICES AND SUPPORT DECISION- AND POLICY- MAKING
TOPICS

- **MANAGEMENT AND STEWARDSHIP** of multi-type, multi-scale, and multi-disciplinary data
- **FEDERATION OF DISTRIBUTED TRANS-NATIONAL DATA SOURCES** and interdisciplinary data-intensive analysis platforms in support of end-to-end analysis and decision making (i.e., the so-called 'glueware' component)
- **OPTIMISING STRATEGIES FOR DATA MOVEMENT** in end-to-end analysis, taking into consideration 'green' approaches (e.g., minimising energy footprint)
- **DATA AND MODEL INTER-COMPARISON** and prediction (DMIP) and validation protocols
- **BRIDGING RESEARCH- AND POLICY-DRIVEN NEEDS**
- **PERVASIVE PROVENANCE SYSTEM** in support of open science data credentials
- **FINDABLE AND SHARABLE SOFTWARE COMPONENTS, STATISTICAL ANALYSIS AND VISUALISATION TOOLS AND LIBRARIES**, eventually provided as a service to a broad community
MORE INFORMATION AND USEFUL LINKS

• SECRETARIAT@BFE-INF.ORG

• HTTP://WWW.BFE-INF.ORG/
DATA ACCESS AND ANALYSIS

Stefano Nativi
(CNR-IIA)
DR3 COMPLEXITY

- Effective Data Access
- Data Integration
- Reliable Communications
- Information/Knowledge generation
- Specific Monitoring
- Collaborative Environment
Data Fabric

Observations
Experiments
Simulations
etc.

[Integrate Interoperate]
Collection Building
Discover Plan

Register, Describe Store, Preserve
Cite Organize

Extract Knowledge
Organize

Plan Collect
New Collection
Processing

[Sensors Simulators]
DATA DRIVEN (EARTH) SCIENCE

Observations & Simulations

Data

- Understand & connect
- Data service (e.g. QA/QC)

Info (Data)

- Understand & connect
- Data processing (e.g. model run)

Know (Data)

- Understand & connect
- Data Analytics

Publications

- Connect & Share
- Data representation

Define/Identify the Problem

Form a Hypothesis

stefano.nativi@cnr.it
Big Data Challenges

THE FOUR V’s
OF BIG DATA

Volume
Scale of Data
- 40 Zettabytes (4.6 Exabyte/year)
- 6 Billion People
- World Population 7 Billion
- 19.9 Billion Network Connections
- 100 Terabytes

Velocity
Analysis of Streaming Data
- 1 TB of Trade Information
- 100 Sensors

Variety
Different Forms of Data
- 420 Million Wearable, Wireless Health Monitors
- 150 Exabytes
- 4 Billion+ Hours of Video
- 30 Billion Pieces of Content
- 400 Million Tweets

Veracity
Uncertainty of Data
- 1 in 3 Business Leaders
- 27% of Respondents
- In one survey were unsure of how much of their data was inaccurate
- $3.1 trillion a year

Source: IBM
WEB-BASED CLOUD HYBRID ENVIRONMENT

- Model-as-a-Service?
- Sensor-as-a-Service?
- Workflow management?
- Best interoperability architecture?
- Infrastructure Flexibility level?
WEB 2.0 PATTERNS

- semantic Web grounding and collaborative tagging
- rich user experience
- user-centered design
- using web as a platform
- Web Service composition
- power decentralization
- participation-collaboration (social) pattern
- openness
- dynamic content
- Software as Service (SaaS)
- data and information supply chain management
- application and data aggregation/mashup
- data and information supply chain management
- participation-collaboration (social) pattern
- power decentralization
- openness
- dynamic content
- Software as Service (SaaS)
- data and information supply chain management
- application and data aggregation/mashup
FROM DATA TO INFORMATION/KNOWLEDGE

Connect and Understand

Principles
Patterns
Best Practices
Relations

Granularity level

(phenomena/process)

Understanding
Principles

Understanding
Patterns and Use

Understanding
Relations

Understand & Connect
VIRTUAL LABORATORY PLATFORMS

Applications, Portals, Marketplace, Dashboards, etc.

Resources management (discovery, access, harmonization, etc.)

Workflows Management

APIs

User feedbacks

User feedbacks

User feedbacks

Satellite Data

Other Platforms

In-situ Data

Processing Algorithms

GitHub

GitHub

Virtual Cloud

Models

Analytic Infrastructures
Automated Data Processing (Model-as-a-Service)

Integrated Modeling analysis

- Problem statement
- Conceptual Integrated Modeling Design
- Integrated Modeling Execution
- Analysis of the Result

Scientist

IT Professional

Business Process design

Workflow execution
THANK YOU!
Scattered thoughts on Disaster Risk, Reduction and Resilience

Antonello Provenzale, CNR IGG

Need for data:
What data, what metadata, how to store, retrieve and distribute them

What do we do with the data:
Data analysis methods
Estimates of uncertainty
Conceptual frameworks
Data analysis methods and prediction

Statistical analysis (correlations)

Empirical models of correlation links

Statistics of extreme events (fat tails and power laws)

Dynamical system approaches and physically-based models
Example 1: Earthquakes
Seismic (and risk) hazard varies with time (in particular in the short-term)

During a seismic sequence (e.g., Kumamoto, 2016; Amatrice-Norcia, 2017) the weekly probability of a destructive earthquake can increase 100-1000 times with respect to the reference level, but this probability barely reaches a few percent. (NOTE: “small” probabilities may lead to unacceptable risk)

Some models based on earthquake clustering provide accurate estimations of such probabilities. Despite the usual belief, such models are verified empirically much better than long-term hazard models for the building code.

OEF models are useful to track the evolution of a seismic sequence (before Tohoku 2011; Christchurch 2010-2011; Kumamoto 2016; Amatrice-Norcia, 2016)
Evolution of the weekly probability with time for the selected area: updated every day or after a M3.5+
Weekly Forecasts for the Amatrice-Norcia sequence (in light blue the earthquake that occurred during the forecasts)

A - just after Amatrice earthquake on August 24 (light blue dots the largest aftershocks observed)
B - before the M5.9 (light blue star) on Oct. 26
C - before the M6.5 (light blue star) on October 27.
D - before the M5.5 (light blue star) on Jan. 18.
Basic (and common) question:
Is the OEF (weekly) probability of large earthquakes too small?
La probabilità settimanale massima per un M5.5+ è stata di $\approx 1/250$. 

**Current weekly Probability:**
- MMI 6+
- MMI 7+
- MMI 8+
- MI 4+
- MI 5.5+

**Center (Location):** 39.85 16.05

**Dimension (km):** 50

**Last run:** 2015/05/12 02:30
**Area Probability:** $1.80 \times 10^{-4}$

**2012/10/26:**
**Area Probability:** 0.004

**Time Evolution of the probability for one or more events with Magnitude greater than 5.5**

$\approx 1/250$
When is the probability of a large earthquake too small? (Marzocchi et al., SRL, 2015)
(a seismic sequence in Italy with largest earthquake M5: the weekly probability of a large earthquake is at most 1/250, but the individual risk of death is above the acceptable risk)
Discussion items

1. Risk reduction requires many different expertises, not only science.
2. Low-probability high-impact events are difficult to manage. Importance of communication (e.g., pandemic and terrorist risks)
3. Seismologists are not able to predict exactly earthquakes but this does not mean that they know nothing. They can make probabilistic forecasts
4. Communicating uncertainties and probabilities. Although it is a hard task, not communicating them is hard a viable option.
5. Decision-making must be based on probabilities (unavoidable uncertainties prevent to make deterministic predictions; at least in most of natural disasters)
Example 2: Hydrogeological/environmental hazard
To estimate future environmental risks, we need impact models.

**Global Climate Models:** The most advanced tools that are currently available for simulating the global climate system and its response to anthropogenic and natural forcings.

**Impact models:**
- Basin response
- Ecosystems
- Glaciers and snow
- Agriculture, Land surface
The downscaling-impact chain

Global climate model

Regional climate model

Impact on eco-hydrological processes

Statistical/stochastic downscaling
The chain of uncertainties: (1) data for model validation
Summer precipitation (JJAS), Multiannual average 1998-2007

The chain of uncertainties: (2) spread between CMIP5 models

And the spread of CMIP5 temperatures

Himalaya JJAS

Himalaya DJFMA

HKK JJAS

HKK DJFMA
Precipitation statistics from WRF (Pakistan Flood 2010)

July 29, 2010

Francesca Viterbo et al., J. Hydrometeorology (2015)
The chain of uncertainties: (3) downscaling

Gabellani, Boni, Ferraris, von Hardenberg, Provenzale
Adv. Water Res. 2007
The chain of uncertainties: (4) local impact models

Climate change and forest fires

Long-term changes $\rightarrow$ human activities, climate trends.

The year-to-year changes in NF and BA are mainly related to climate variability.

The climate acts mainly on two aspects:
(i) antecedent climate $\rightarrow$ fuel to burn; (ii) coincident climate $\rightarrow$ fuel flammability.

Climate drivers = both interannual variability and trend are driven by climate
All drivers = MLR considers the year-to-year climate variation + overall trend
Impact of future climate change on wildfires

- Future response depends on management strategies
- Uncertainty in RCM scenarios is larger than impact model uncertainties for forest fires
We need ... a Solid Earth systems model: An approach to structuring distributed knowledge of the science of geology to provide an integrated view in the context of sciences of the solid Earth as a whole. A model of the systems of the solid Earth, organised within a framework that depicts and clarifies the principal relationships among the ... multiple ... findings of geology, providing a multidimensional map to locate and connect ideas, concepts, workflows of investigation and threads of reasoning.


We need new research, not only application of existing results
Disaster Risk Reduction and Resilience: A Global Imperative for Earth System Sustainability

Belmont Forum Scoping Workshop on Disaster Risk, Reduction and Resilience

Hassan Virji

Academia dei Georgofili
Florence, Italy
June 5-7, 2017
Disaster resilience is everyone’s business and is a shared responsibility among citizens, the private sector, and government. Increasing resilience to disasters requires bold decisions and actions that may pit short-term interests against longer-term goals.

A global risk is an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the next 10 years.
Risk is systemic, complex and dynamic
The SFDRR Context:

- During 2005 to 2015 [700,000 people lost their lives, 1.4 million injured, 23 million homeless, 1.5 billion affected. Economic loss: 1.3 trillion USD]

- More small scale disasters and slow onset disasters

- People centered preventive approach

- Engagement of stakeholders

- Need to link to SDGs, climate change framework

- Role of Science and Technology in EWS, preparedness, response, recovery, rehabilitation and reconstruction
Sendai Framework for Disaster Risk Reduction 2015-2030

The post-2015 development agenda, financing for development, climate change and disaster risk reduction …

Ensuring credible links, … between these processes will contribute to building resilience and achieving the global goal of eradicating poverty.” … action within and across sectors by States at local, national, regional and global levels

Four priority areas for Disaster Risk Reduction

1. **Understanding** disaster risk;
2. Strengthening **disaster risk governance** to manage disaster risk;
3. **Investing** in disaster risk reduction for resilience;
4. Enhancing disaster preparedness for effective response, and to “**Build Back Better**” in recovery, rehabilitation and reconstruction.
Likelihood

Impact

Extreme Weather Events

Risks

Water crises

Failure of climate change mitigation and adaptation

Natural Disasters

Large-scale involuntary migration

Man-made Environmental Disasters

Profound social instability

Governance

Spread of infectious diseases

Food crises

World Economic Forum - Global Risks 2017
Disaster Risk, Climate Change, Poverty, Health, Development and Governance are linked issues.

Need for integrated “transdisciplinary” science
2. Affected populations: lower average number of people affected per 100,000 in 2020–2030 compared with 2005–2015.
4. Critical infrastructure: substantially reduce damage and disruption of services by 2030.
5. Risk reduction strategies: substantially increase the number of countries with national and local strategies by 2020.
6. Implementation support to developing countries: substantially enhance support to complement national actions by 2030.
7. Multi-hazard warning systems and risk information: substantially increase their availability by 2030.

How can we measure disaster loss reduction in the absence of reliable loss data on the economic and human impacts? Existing loss accounting systems vastly underestimate the true burden of disasters, both nationally and globally.

— Sendai targets at risk – S. Cutter and M. Gall - Nature Climate Change, 2015
SFDRR: Four Priority for Actions

1. Understanding disaster risk
2. Strengthening disaster risk governance
3. Investing in risk reduction
4. Enhancing disaster preparedness for collective response, and to “build back better” in recovery, rehabilitation and reconstruction
SUSTAINABLE DEVELOPMENT -
“Humanity has the ability to make development sustainable - to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs”
1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote well-being for all at all ages
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development
In the Cancún High-Level Communiqué, the leaders committed to implement the Sendai Framework for DRR in coherence with the Sustainable Development Goals (SDGs), the Paris Agreement on climate change and the New Urban Agenda; and promote people-centered, gender-sensitive, accessible and resilient urban development that supports all of society, including the vulnerable, the poor and the marginalized.
Definition of Resilience

Resilience - The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.
Resilience needs to address potential loss and damage + future risk
Pre-disaster Recovery Planning is strategic to resilient development.

Pre Disaster Recovery Planning (PDRP) is any planned attempt to strengthen disaster recovery plans, initiatives, and outcomes before a disaster occurs. (IRP)
PDRP enables bouncing forward vs. bouncing back

Social transformation for potential next hazards

Better Recovery
Quick Recovery
Low Recovery

Social learning

Benefit of PDRP

Time

Maki, Otsuyama, Yuda, Sasaoka, Santiago, Pribadi, 2017
- Mitigating, preparing for and building resilience against global risks is a long and complex process and difficult in practice.

- **Global risks transcend borders** – capacity and authority to act?

- Effective communication to the public, government, business and civil society.

- Prediction - **Keys**: linking social, economic, technology, science and environmental issues and the future with the present

- Early warning system - *timely and meaningful warning information* - prepared and act appropriately and in sufficient time to reduce harm or loss. Preparedness - knowledge and capacities …
Societies face increasing complexity and uncertainty in decision making to cope with extreme weather events. Therefore oversimplified risk approaches should evolve to much richer resilience strategies. Yet, resilience is often more a policy buzzword or topic for theoretical debate than an actual operational paradigm. It is often not clear for policy makers and practitioners how they can translate the main notions of resilience thinking into practical implementation.

‘Environmental Science & Policy’, April 2017, Institute of Water Policy of the National University of Singapore, the Faculty of Technology, Policy and Management of the Delft University of Technology and Deltares
Five practical principles to develop strategies that enhance resilience to disasters

1. **Importance of a **systems approach**: Understanding of the entire system under risk of extreme weather events - including the physical, environmental, social and economic aspects and how they are connected - is required to define societal effective measures.

2. **Focus on beyond-design events**: Rare events with disastrous and lasting consequences may call for protection against higher costs than justified by a standard cost-benefit analysis. A resilience approach considers the entire possible spectrum of events as opposed to a risk approach which often focuses on design events. It stimulates thinking about the worst case, or even unimaginable scenarios.

3. **Ensure infrastructure robustness to disasters**: The consequences of failure are not catastrophic, but manageable e.g. because critical infrastructure remains in service. Making sure that a system remains functioning during extreme events acknowledges the fact that the possibility of failure cannot be eliminated altogether, and is typical for resilience thinking.

4. **Increase the recovery capacity of a society**: The long-term impact of an extreme event partly depends on the time it takes to recover. The capacity to recover depends on social capital (the individual ability of people to recover), institutional capital (the ability to organise repair and reconstruction), and economic capital (the ability to finance repair and reconstruction).
• Become **resilient into the future**: Flexibility, the ability to learn, the capacity to adapt and the willingness to transform if necessary are crucial to cope with gradual but uncertain changes. It is important to realize that the current resilience of a system may be exhausted due to gradual geophysical developments such as climate change or subsidence, and socio-economic developments such as migration, conflicts, urbanization and economic growth.
Knowledge & Practice

Scientific Knowledge

Field Practice
Problem versus Solution

Social Problem

Engineering Problem

Engineering Solution

Social Solution
Culture of Preparedness for Effective Env./Disaster Management

Culture

Education (Learning)

Practice (Implementation)

Tradition (Time)
Risk Communication Framework

Information sender

Specialists
Officers
INGOs
Researchers

Needs and concerns
Two-way Interactive
Needs related risk information

Information receiver

Local people
NGOs
① Necessity of Holistic learning

② Necessity of Facilitator

③ Trust with Communities
Policy Issues for Science and Society

**Responsibilities of global science**
To contribute to post-2015 frameworks, including the Sendai Framework, Agenda 2030, Paris Climate Agreement and the upcoming agenda.  
*SDG 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development*

**Develop fully global science capacity**
Science for the benefit of all societies and “leaving no scientists behind”

**Science and Technology for Sustainable Development**
Projecting science, technologies and societal change

**Challenging science policy and practice**
Time to create the ‘conditions of possibility’, to support science for a sustainable and just world
Integrated Actions on Disaster Risk Reduction

Intersecting Issues:
- cities, energy, economy resilience, people, health, … effective decision making

Intersecting Agendas
- Climate change
- Disaster Risk Reduction
- Sustainable Development

Integration of global-national-local research and programs

Capacity Enhancement
Regional Offices

Big Science
Open Data

Integrated Science to Policy
Integrated science

• Works across disciplines and fields - (interdisciplinarity)
  • Supporting the joint, reciprocal framing, design, execution and application of research

• Works globally - (international collaboration)
  Including the agendas, perspectives, approaches, methods and models of scientists from all parts of the world

• Works with society – (trans-disciplinarity)
  • Engaging decision makers, policy shapers, practitioners, as well as actors from civil society and the private sector as partners in the co-design and co-production of solutions-oriented knowledge, policy and practice

• Science to Policy – via epistemic process – IPCC, IPBES, DRR science assessment, SDG science assessment – integrated assessment process
Conclusion: The Importance of City Governance

For rapid urbanization to provide opportunities to all, carefully considered urban planning and good governance with effective regulatory frameworks are required. Inadequate planning and ineffective governance can bring significant economic, social and environmental costs, threatening the sustainability of urban development.
Urban Areas – Challenges for Disaster Risk Reduction, Climate Change and Sustainable Development

- Food
- Migration
- Water crises
- Natural Catastrophes
- Extreme Weather Events
- Health
- Capacity

- Biodiversity loss and ecosystem collapse
- Failure of national governance
- Failure of urban planning
- Capacity
We need to address issues of international and intergenerational equity and ethics – science for evidence-based policies for all.
Cape Town contends with worst drought in over a century

By Derek Van Dam, CNN Meteorologist

Updated 2:39 PM EDT, Wed May 31, 2017

Cape Town Needs a Miracle (04:12)
...we have two choices:

• **We can maintain the status quo** and move along as we have for decades—addressing important, immediate issues such as the solvency of the National Flood Insurance Program, the most effective ways to discourage development in high-risk areas, and how to improve the speed and effectiveness disaster response.

Or,

• **We can embark on a new path**—one that also recognizes and rewards the values of resilience to the individual, household, community, and nation. Such a path requires a commitment to a new vision that includes shared responsibility for resilience and one that puts resilience in the forefront of many of our public policies that have both direct and indirect effects on enhancing resilience.

Thank you for your attention