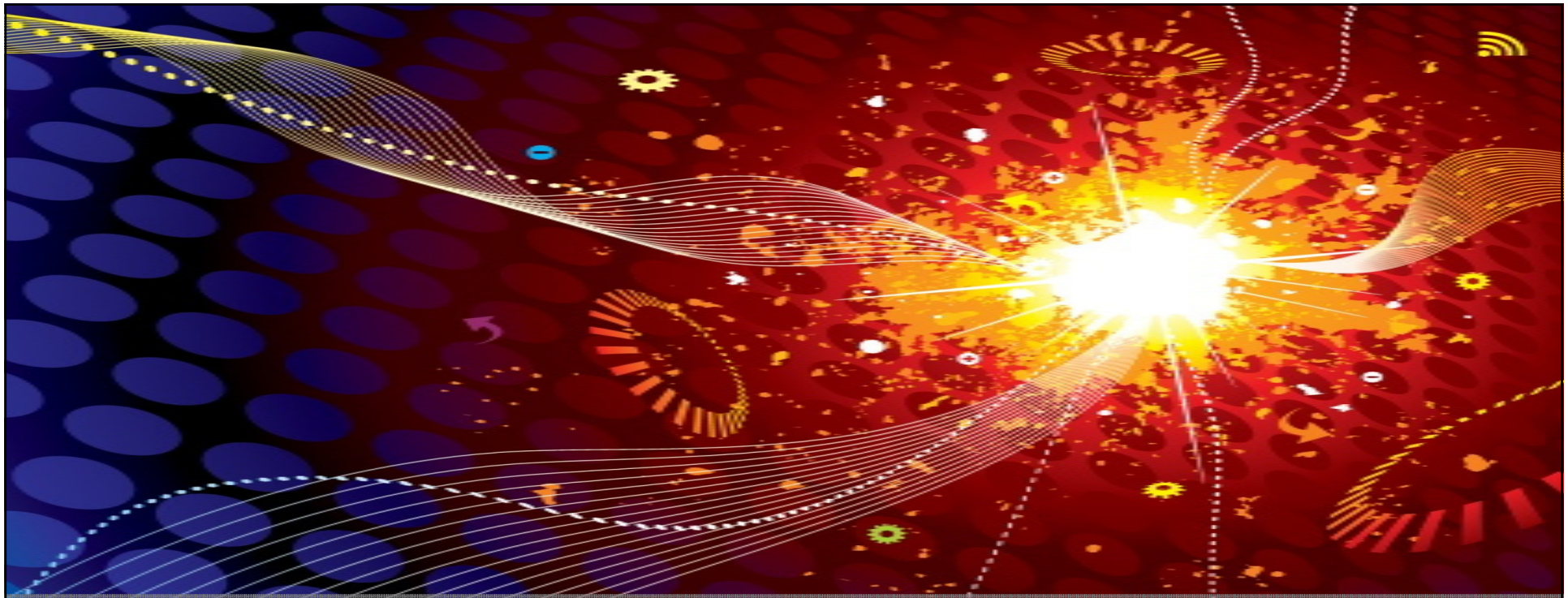


A Shock to the System

A Research Programme of the Cambridge Centre for Risk Studies

Taxonomy of Macro-Threats

Version 2.0

Centre for Risk Studies

UNIVERSITY OF CAMBRIDGE
Judge Business School

Context for the Development of a Threat Taxonomy

- The Cambridge Centre for Risk Studies is compiling information on potential 'system shocks' (socio-economic catastrophes) for use in risk management
- We are developing a repository of information about each potential cause of future shocks – the 'Threats'
- Each threat is being profiled
  - to provide an assessment of the state of knowledge
  - to standardize procedures to provide objective, evidence-based assessments of the relative importance of each threat
  - to derive scenarios that can be used as stress tests for risk management
- The taxonomy of threats provides the framework for the compilation of information

Focus on Global Threats

- To enable the threat information compilation tasks to be tractable, we are initially limiting the efforts to the greatest threats
- These are global threats, capable of impacting multiple countries
- We have termed these ‘Macro-Threats’
- We have set thresholds for the selection of Macro-Threats
- At regional or local levels, different threat types and severities may be more significant
  - These could potentially be incorporated in the future by extending the framework and setting different thresholds for inclusion

Definition of Macro-Threat

- A potential cause of a socio-economic catastrophe that would threaten human and financial capital, damage assets, and disrupt the systems that support our society, at a national or international level

Criteria for inclusion:

- An event of this type has occurred in the past 1,000 years, or could occur somewhere in the world with an annual likelihood of greater than 1 in 1,000 (0.1%), with impacts in a single year above at least one of the following minimum thresholds:
  - **Human Injury**: Kill more than [**1,000**] people or injure or make seriously ill more than [**5,000**] people
  - **Disruption**: For a major region or nation, or for a particular international business sector, it would cause normal life patterns and commercial productivity to be substantially interrupted for more than [**one week**]
  - **Cost**: Physical destruction of property and infrastructure costing [**$10 billion**] to replace, or similar level of loss of value of assets
  - **Economic impact**: At least one country loses at least [**1%**] of Gross Domestic Production

Note that these are minimum thresholds for the inclusion of the class of threat on our taxonomy. The criteria are intended to eliminate smaller types of threat that might cause localized severe impacts but not register on a global scale. The thresholds are proposed to help prioritize the focus and resources of the System Shock project.

Approach

- For a threat classification system to be useful, it has to be
  - Tractable: a manageable number of categories and classes
  - Wide ranging: to cover as many causes of threat as possible.
- This means we will develop limited numbers of classes of threat that are necessarily large and imprecise.
- The intent is to capture the broad **types** of threats: ones that might impact our systems in different ways to the others.
- We don't expect to anticipate every future threat, but we do intend to ensure that all avenues of scientific evidence and exploration are represented in the categorisation.

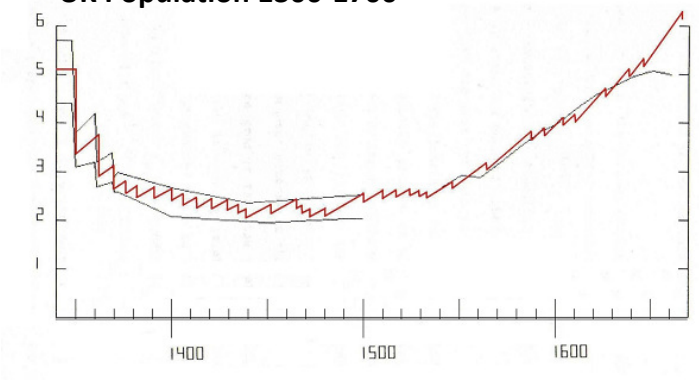
Our Approach to Completeness

- We are taking a systematic approach to categorization of threats using the following methods:
- Review of long term historical data (as far back as possible) on disruptions to human social systems
- Identify the types of causal mechanisms ('threat categories') that gave rise to the disruptions
- Recognize that historical catastrophes have
  - Universal processes (independent of historical era)
  - Contemporaneous mechanisms (specific to the era)
- We are interested in the universal processes, not the contemporaneous mechanisms, in identifying threats
- We also systematically review scientific conjecture about threats that have not appeared in the historical records, but for which evidence exists to support a threat assessment
- We subject the categorization to peer review

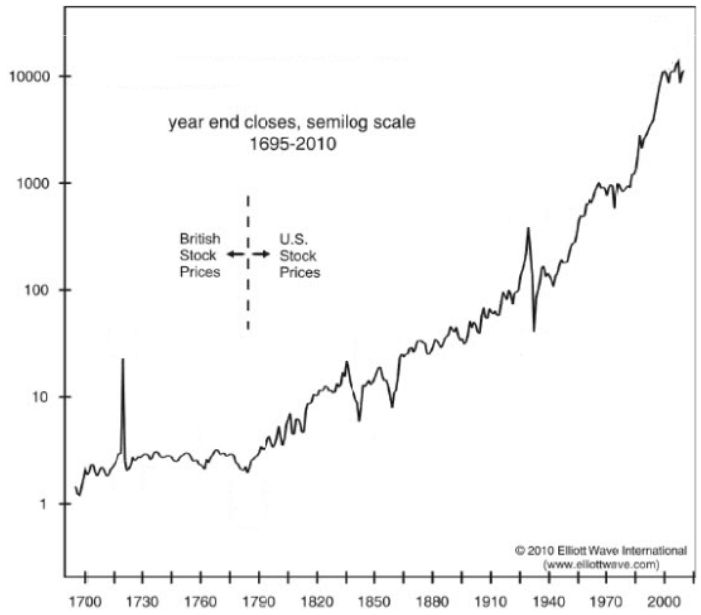
Approach to Evidence-Based Completeness

- We are reviewing a thousand years of data for historical events causing disruption to social life and economic well-being
- Categorization of causes
  - Primary effort is to ensure that all categories are captured
  - Identify drivers of risk
- Counter-Factual History
  - Near-miss events that could have caused catastrophe with plausible minor deviations from actual events
- Scientific publications proposing mechanisms for major disruptions that do not appear in the historical records
  - Climate change; new technology hazards; changes in frequency and severity of threats

UK Population 1300-1700



300 years of Stock Market records



Source: Jay (2010)
http://fintrend.com/tag/bear-market/

What Will We Do With This Taxonomy?

- The taxonomy will be used to structure a catalogue and information resource on these threat classes.
- We intend to expand this web site over time to provide a state-of-knowledge summary for each threat class.
- For each threat class we propose to develop one or more scenarios that can be used in shock tests.
- The objective is to produce a set of scenarios that will be consistent, objective, transparent and evidence-based, and useful in business decisions.
- These will be published and made available to the risk management community on this site.

Profile of a Macro-Threat Class

For each individual Threat Class we propose to present:

- State-of-knowledge compilation of the science
- Catalogue of Historical Events
- Identify or define an index of severity ('magnitude scale')
- Assess the magnitude-recurrence frequency (worldwide)
- Geography of threat
- **Illustrative 'Stress Test' scenarios of large magnitude events**
  - For e.g. 1 in 10, 1 in 100 or 1 in 1000 annual probability
- System impact (vulnerability) knowledge
- Assessment of uncertainties

Profile of a Threat Category

For each threat category we propose to create an information resource summarizing the state of knowledge about the threat, consisting of:

1. **Short Definition** (one or two sentences)
2. **Overview**: Summary of the threat, what is known about it and the kind of threat it poses, and to whom
3. **History**: A short summary of the threat through history, referencing a summary table listing notable historical incidences of the threat (the list of events will be structured as a database, with a set of standard fields providing information about the event). We want this to look back as far into history as is possible.
4. **Magnitude scale**: Definition of a magnitude scale or index for an event of this type. Preferably adopting one that some authority has already proposed or is in use
5. **Geography of hazard**: Map indicating where events of this type are most likely, regional zonings of the world to identify locations of highest threat
6. **Historical event examples**: A description of selected historical events, including a map of the geographical extent of the 'footprint' of the event and additional information about the consequences of the event.
7. **Bibliography**: key literature references about the subject, and recommended reading
8. **Information Resources**: Listing of sources of information to obtain further information on the subject, institutions currently working on the problem, and leading academics or authorities working in the field

Categorization

Macro-Threats have been categorized into:

- 47 categories of macro-threat, within
- 12 primary classes

- Primary classes are broad conceptual divisions that can be considered as independent causes, to a first order.
  - This means that the **causal mechanisms** that give rise to an event in this class of threat are separate processes
  - We fully recognize that classes are not truly independent , and that an event of one class can cause another to occur
  - This is explicitly considered in our correlation relationships, discussed later in this presentation

Implications of the Threat Taxonomy

- Each threat category produces rare catastrophic events – each on their own might be dismissed as too rare to worry about
- The threat taxonomy has identified 47 different categories of macro-threat
- We propose to identify and illustrate a representative scenario of a '1-in-100' event for this category
- These macro-threat types are not completely independent, but if they were, **you could expect to experience an event within the '1-in-100' range** from one or other of the threat categories, somewhere in the world **every two years**
- You could expect to see a 1-in-1000 year event from one or other of the threat types once every 20 years

Taxonomy of Macro-Threats

A framework for categorising socio-economic threats and collecting structured data

1 Financial Shock

1.1 Asset Bubble
1.2 Financial Irregularity
1.3 Bank Run / Credit Default
1.4 Sovereign Structural Failure
1.5 Market Volatility

2 Trade Dispute

2.1 Labour dispute
2.2 Trade Sanctions
2.3 Tariff Wars
2.4 Nationalization
2.5 Cartel Pressure

3 Geopolitical Conflict

3.1 Conventional War
3.2 Asymmetrical War
3.3 Nuclear War
3.4 Civil War
3.5 External Force

4 Political Violence

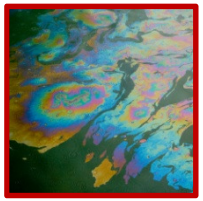
4.1 Terrorism
4.2 Separatism
4.3 Civil Disorder
4.4 Assassination
4.5 Organized Crime

5 Natural Catastrophe

5.1 Earthquake
5.2 Windstorm
5.3 Tsunami
5.4 Flooding
5.5 Volcanic Eruption

6 Climatic Catastrophe

6.1 Drought
6.2 Freeze Event
6.3 Heat Wave



7 Environmental Catastrophe

7.1 Sea Level Rise
7.2 Oceanic Circulatory System Change
7.3 Atmospheric System Change
7.4 Pollution Event
7.5 Wildfire

8 Technological Catastrophe

8.1 Nuclear Power Plant Accident
8.2 Industrial Accident
8.3 Infrastructure Breakdown
8.4 Technological Accident
8.5 Cyber-Catastrophe

9 Disease Outbreaks

9.1 Human Epidemics
9.2 Animal Epidemics
9.3 Plant Epidemics

10 Humanitarian Crisis

10.1 Famine
10.2 Water Supply Failure
10.3 Population Migration
10.4 Welfare System Failure

11 Externalities

11.1 Meteorite
11.2 Space Weather

12 Other Shock

Community peer review being conducted at http://systemshock.org.uk

Primary Categories of Macro-Threats

1
Financial
Shock

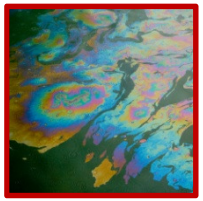
2
Trade
Dispute

3
Geopolitical
Conflicts

4
Political
Violence

5
Natural
Catastrophe

6
Climatic
Catastrophe



7
Environmental
Catastrophe

8
Technological
Catastrophe

9
Disease
Outbreak

10
Humanitarian
Crisis

11
Externality

12
Other
Shock

Correlation

- Some of the worst manifestations of events involve the triggering of one event category by another
  - A cascade catastrophe
  - For example, an earthquake could cause damage that will cause a nuclear power plant meltdown, and this could trigger a financial shock in the markets
- This is considered in a qualitative structuring of the causal and consequential correlation matrix for the threat taxonomy

Causal and Consequential Correlation of Threats

Consequential Threat

Primary Trigger

		1 Financial Shock	2 Trade Dispute	3 Geopolitical Conflict	4 Political Violence	5 Natrual Catastrophe	6 Climatic Catastrophe	7 Environmental Cat	8 Technological Cat	9 Disease Outbreak	10 Humanitarian Crisis	11 Externality	12 Other
1	Financial Shock	4	3	2	2	1	1	1	1	1	2	1	1
2	Trade Dispute	3	4	2	3	1	1	1	1	1	1	1	1
3	Geopolitical Conflict	3	2	4	3	1	1	1	1	1	2	1	1
4	Political Violence	2	2	3	4	0	0	0	3	3	2	1	1
5	Natural Catastrophe	2	2	2	1	4	2	3	3	2	2	1	1
6	Climatic Catastrophe	3	2	3	2	3	4	3	2	2	3	1	1
7	Environmental Catastrophe	3	2	2	2	3	3	4	2	2	2	1	1
8	Technological Catastrophe	2	2	2	2	2	2	0	4	1	1	1	1
9	Disease Outbreak	3	2	1	1	1	1	1	2	4	2	1	1
10	Humanitarian Crisis	2	2	3	3	1	1	1	1	2	4	1	1
11	Externality	3	2	2	1	3	3	3	3	2	2	1	1
12	Other												

0	No causal linkage No ability to exacerbate
1	**No causal linkage**, but would exacerbate consequences if they occur
2	**Weak potential** to trigger threat occurrence
3	**Strong potential** to trigger threat occurrence
4	Ability to trigger **Other threats within same type class**

Taxonomy of Macro-Threats

Version 2.0

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Macro-Threat Primary Category

1 Financial Shock

Events in the financial system causing short-run fluctuations and/or significant changes in long-run economic growth

Threat Class	Description	Historical Examples
 1.1 Asset Bubbles	Pricing inflation and sudden collapse for a major sector or asset class	2008 Sub-Prime Property Bubble 1999 'dot com' bubble 1999 1637 Amsterdam Tulip bubble 1720 South Sea Bubble
 1.2 Financial Irregularities	Fraud, rogue trader(s), Ponzi scheme(s) or other major irregularity	1995 Nick Leeson, Barings Bank 2008 Jerome Kerviel ($7Bn) Societe Generale; 2009 Bernard Madoff ponzi scheme ($18 Bn)
 1.3 Bank Run	Credit default for major banks, banking system or market participant	U.S. savings and loan crisis of the 1980s and 1990s 2007 run on Northern Rock (UK)
 1.4 Sovereign Failure	Debt default, currency devaluation or government failure	Black Wednesday UK Government withdrawal from ERM 1992 Russian crisis and LTCM 1994 Argentina crisis of 2001-2002
 1.5 Market Volatility	Extreme correlated mass movement of share prices , possibly driven by information or perception about economic fundamentals	Stock Market Crash of 1987

Macro-Threat Primary Category

2 Trade Dispute

Events causing widespread change or disruption to international trading conditions

Threat Class	Description	Historical Examples
 2.1 Labour Dispute	Strikes, mass refusal of employees to work, or picketing by aggrieved workforce to prevent commercial activity	UK General strike 1926; US Longshore strike1949; UK Miners' strike 1984-5
 2.2 Trade Sanctions	Embargos and blockades of trade by one country on another, including the unilateral denial of commercial flows, goods, or services	2009 Russia-Ukraine Gazprom dispute disrupts gas supplies to Europe
 2.3 Tariff Wars	Protectionism through the imposition of taxation of a particular set of goods or services	2009 US tax on Chinese tyres; reciprocated by Chinese tax on US Chicken imports
 2.4 Nationalization	Sovereign appropriation of foreign-owned assets in that country	1956 Egypt nationalization of Suez canal, 1972 Pakistan nationalization of foreign assets
 2.5 Cartel Pressure	Trading bloc of suppliers applies pricing or supply pressures	1973 Opec Oil Crisis oil embargo "in response to the U.S. decision to re-supply the Israeli military"

Macro-Threat Primary Category

3 Geopolitical Conflict

Military engagements and diplomatic crises between nations with global implications

Threat Class	Description	Historical Examples
 3.1 Conventional War	Dispute between two or more nations resulting in military conflict, including bombardment, invasion of troops, or other destruction of infrastructure	Falklands War 1982; Gulf War Kuwait & Iraq 1990-1, Gulf War 2, Iraq , 2003; World War II 1939-45;
 3.3 Asymmetric War	Insurgency and violent resistance carried out by	
 3.3 Nuclear War	Military conflict pursued using nuclear weapons	Bombing of Hiroshima and Nagasaki in Japan 1945; Near-misses include Cuban missile crisis
 3.4 Civil War	Internal conflict within a country	Darfur, Sudan 2009; Bosnia 1992-5;
 3.5 External Force	Blockades, No-Fly zones, missile attack or other military action by external forces to prevent national authorities pursuing internal policies deemed harmful or repugnant	No-Fly Zone, Northern Iraq, 1991; NFZ Bosnia and Herzegovina, 1993–5; Libya? Israeli sea and land blockade of the Gaza Strip, since 2002; Co-ordinated blockade of Armenia by Turkey and Azerbaijan 1994

Macro-Threat Primary Category

4 Political Violence

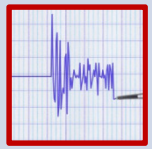
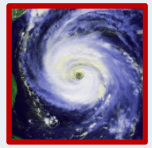
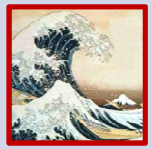
Acts or threats of violence by individuals or groups for political ends

Threat Class	Description	Historical Examples
 4.1 Terrorism	Terrorist attack perpetrated by a group for political ends	World Trade Center Attack by Al Qaeda 2001; Sarin gas attack Tokyo Subway by Aum Shinrikyo 1995;
 4.2 Separatism	Sustained campaign of violence for regional independence	Sri Lanka, Tamil Tigers
 4.3 Civil Disorder	Riots, civil disobedience, mass protests and violence, revolution	Fall of Berlin Wall 1989, Palestinian Intifada 2000-; France banlieues riots 2005; Arab Spring 2011
 4.4 Assassination	Assassination of a major political leader and the political turmoil that results	Assassination of JFK 1963; Attempt on Reagan 1981; Benazir Bhutto 2007;
 4.5 Organized Crime	Crime wave, campaign of criminal extortion, piracy, or mass illegal activities	Somalia Piracy in Horn of Africa 2005-2010; Piracy in Strait of Malacca 2004; ; First Mafia war, Italy, 1962; Mexican Drug War 2006;

Macro-Threat Primary Category

5 Natural Catastrophe

Naturally occurring phenomena causing widespread disruption

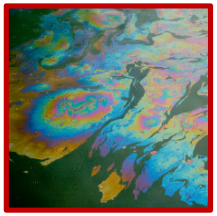
Threat Class	Description	Historical Examples
 5.1 Earthquake	Seismic fault rupture causes high levels of damage to infrastructure of a major populated area	Kobe Earthquake, Japan, 1995 Tokyo earthquake 1923 San Francisco earthquake 1908 Tohoku earthquake, Japan 2011 Northridge, California, 1994
 5.2 Windstorm	Hurricane/typhoon/cyclone wind system makes landfall onto a major populated area; European-type windstorm system, large scale, fast-moving, gale force wind speeds	Hurricane Katrina, USA, 2005; Hurricane Andrew, USA, 1992 European Windstorm Lothar 1999 Typhoon Mireille, Japan, 1991
 5.3 Tsunami	Coastal impact of a tidal wave, caused by offshore earthquake, marine landslide, or meteorite in the sea,	Boxing Day Tsunami 2004, Japan Tohoku 2011
 5.4 Flood	River Flood: High rainfall across one or more river system catchment areas, snow melt or other sudden water release causes rivers to burst their banks; Coastal Flood: sea surge from low pressure weather systems, and exceptional tides and winds causes sea water incursion inland	River: Queensland Australia 2011; Coastal: East Coast UK 1953
 5.5 Volcanic Eruption	Ash, pyroclastic hot gasses, lava, and lahar-triggered mudflows cause localized destruction and regional disruption	Ash eruption of Eyjafjallajökull, Iceland 2010; Pinatubo eruption, Philippines, 1990

Macro-Threat Primary Category

6 Climatic Catastrophe

Climatic anomalies causing extreme and unusual weather conditions

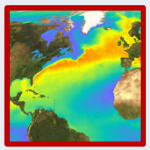
Threat Class	Description	Historical Examples
 6.1 Drought	Extended period of below-average precipitation	1976 Drought in Europe Chinese Drought of 1941 American Dustbowl Drought 1930s Sahel Africa Droughts of 1970s
 6.2 Freeze Event	Extended period of below-average temperatures	Ice Storm Canada 1998; Ice Storm Idaho USA 1961 UK Dec 2010; Moscow, Russia, 2010
 6.3 Heatwave	Extended period of above-average temperatures	Russia 2010; US Heatwave 1980 Chicago Heatwave 1995



Macro-Threat Primary Category

7 Environmental Catastrophe

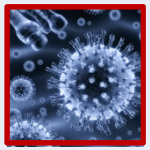
Crises leading to significant and widespread change to environmental or ecological equilibriums

Threat Class	Description	Historical Examples
 7.1 Sea Level Rise	Thermal expansion of the oceans or sudden ice shield melt changes sea level and coastline geography	Interglacial sea level rises in previous epochs
 7.2 Ocean Circulatory System Change	Sudden switch in the circulatory systems of the ocean, such as the Gulf Stream, caused by salination or thermal changes, causes regional climatic change	'Broecker' event 9,000 BC
 7.3 Atmospheric Circulatory System Change	Rapid or sustained periods of change in patterns of meteorological circulation, such as jet stream, causes regional climatic change	'Dansgaard-Oeschger' events 11,500 years ago
 7.4 Pollution Event	Spillage or major release of toxic chemicals into land or sea systems that causes environmental destruction	BP Oil Spill Deepwater Horizon 2010; Exxon Valdez oil spill 1989; Niger Delta Oil Spill 1998 Japan Mercury Pollution of Minamata Bay, 1956
 7.5 Wildfire	Major forest fire, sudden erosion or man-made destruction that causes a major change in landscape or productive environment	Oakland, California, Fire, of 1991 Great Peshtigo Wild Fire, Wisconsin, 1871 New South Wales, Australia, Bush Fire, 2003 Indonesia Forest Fire 1982

Macro-Threat Primary Category

8 Technological Catastrophe

Accidental or deliberate industrial events affecting local and global stakeholders

Threat Class	Description	Historical Examples
 8.1 Nuclear Meltdown	Major core meltdown of a nuclear power station, causing radioactive fallout over a large area of population and economic and agricultural productivity	Chernobyl reactor disaster 1986, Three Mile Island 1979 Fukushima Daiichi Japan 2011 Windscale, UK, 1957
 8.2 Industrial Accident	Fire, explosion or release of toxic chemicals from an industrial complex, storage facility or during transportation	Toulouse France Explosion 2001; Union Carbide Factory; Bhopal India 1984 Bunsfield UK, 2005 Texas City Disaster, USA, 1947
 8.3 Infrastructure Failure	Blackouts in the electricity supply network and other systems failures due to accidents and technical breakdowns	Great New York Blackout of 2003; Enron California brown-outs 2000
 8.4 Technological Accident	New technological advance proves to have unexpected societal effects and causes disruption or harm to human populations	Bisphenol A (BPA) ban from use in baby bottle manufacturing, 2010
 8.5 Cyber-Catastrophe	Computer networks, communications and information technology systems destabilized by computer virus, hacking, denial of service attacks or other cyber-security issues	Pentagon Cyber Attacks, March 2011 Adidas Cyber Attacks 2011 'Flash Crash' cyber stock crash 6 May 2010; MyDoom/Novarg worm 2004; 'I Love You' Virus 2000;

Macro-Threat Primary Category

9 Disease Outbreak

Disease outbreaks affecting humans, animals and/or plants

Threat Class	Description	Historical Examples
 9.1 Human Epidemics	Influenza pandemics, emerging infectious diseases and re-emergent disease epidemics that cause death and illness in human populations	Influenza Pandemic 1918; 2009 Swine Flu Pandemic; HIV/AIDS 1982+; SARS 2002
 9.2 Animal Epidemics	Diseases in animals that cripple agricultural production of meat and poultry or destroy wildlife	Mad Cow Disease (BSE) Epidemic, UK, 1987 Swine Fever, Netherlands, 1997 Foot & Mouth cattle epidemic, Korea, 1997
 9.3 Plant Epidemics	Diseases in plants that impact food production in many agricultural areas or cause destruction of the ecological environment.	Dutch Elm Disease, Europe, 1960s Sudden death syndrome (SDS) in soybeans US Corn Belt 2010; Wheat Stem Rust Outbreak, USA, 1962 Wheat Stem Rust Outbreak, West Africa, 1999

Macro-Threat Primary Category

10 Humanitarian Crisis

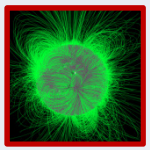
Impact of conditions on mass populations

Threat Class	Description	Historical Examples
 10.1 Famine	A large population suffers failure of their food supply, food distribution, or agricultural production system.	Great Chinese Famine of 1959-1961; North Korean Famine 1996; Soviet Famine 1932-3; Dutch famine 1944; Bangladesh Famine 1974; Ethiopia Famine 1998-2000; Biafra Famine 1967-70;
 10.2 Water Supply Failure	A large population suffers failure of their water supply due to water resource conflicts, river diversion, aquifer depletion, or other cause	Euphrates conflicts Turkey, Syria and Iraq; Battle of Beersheba 1917 over water resources for Palestine; Nile river conflicts Egypt, Ethiopia and Sudan; Cochamba Water Wars, Bolivia, 2000
 10.3 Population Migration	Mass population movements cause instability and collapse of social infrastructure in the areas newly populated and depopulated	US Mass Migration to the industrial north 1930s India-Pakistan partition 1947 Economic migration of Latin Americans to North America
 10.4 Welfare System Failure	Collapse of pension schemes, health programs and social security systems leading to deprivation and hardship for dependents. Breakdowns triggered by underfunding, and imbalances e.g. ageing populations	Post-Soviet 'shock therapy' dismantling of welfare system in Russia 1992; Municipal Pension Defaults, US cities, 2010 New Jersey Pension Fund insolvency, 2009 Ireland state pension credit downgrade, 2008

Macro-Threat Primary Category

11 Externality

Extra-terrestrial threats from astronomical objects and space weather

Threat Class	Description	Historical Examples
 11.1 Meteorite	Ground impact of meteors that cause localized destruction, and dust clouds capable of causing periods of ash winter	Tunguska meteorite explosion, Russia 1908; Chicxulub Crater, Yucatan, Cretaceous–Tertiary extinction event
 11.2 Solar Storm	Solar flare activity that can impact satellites, communication technology, power distribution systems and other infrastructure	Carrington Event geomagnetic storm of 1859;