Resilience and the Threat of Natural Disasters in Europe

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Introduction

This paper focuses on the existential threat of natural hazards. History and recent experience tell us that the most constant, and predictable, hazard in Europe is that of widespread flooding with storms, often with hurricane force winds, slamming the coastal area and causing flooding inland as well.

The modern world is seemingly plagued with the scourges of the Old Testament: earthquakes, floods, tsunamis, volcanoes, hurricanes and cyclones, wildfires, avalanches and landslides. Hundreds of thousands, if not millions, have perished globally in natural hazards, falling victim to extreme forces of nature.

None of these perils are new to civilization. Both the Gilgamesh Epic[1] and the Old Testament talk of epic floods.[2] The Egyptians faced ten plagues. The Minoans, Greeks, Romans, Byzantines, and Ottomans experienced earthquakes, tsunamis, volcanic eruptions, and pestilence. A cyclone destroyed Kublai Khan's invasion fleet of Japan on August 15, 1281. A massive earthquake in Shaanxi Province, China on January 23, 1556 is estimated to have killed 830,000 persons.

A discussion of extreme hazards often involves a common misconception of 100 year floods, 500 year floods, 200 year returns, and similar periods. A mistaken belief is that a "100 year" flood only occurs once a century. The measurement period is a statistical average over an extended period of time. It is not a means of forecasting. It means that on average a storm of that magnitude will occur once in a hundred years, but these storms could be back to back. For example, the German city of Grimma was flooded in 2002 and 2013. Both events were "100 year" floods.[3]

"Extreme" natural hazards have always been with us. They are "extreme" for four reasons; they are often unforeseeable, frequently unavoidable, and perhaps only partially controllable.

The fourth reason is that they become extreme when they affect people. Nature has always had extreme forces, but little notice is taken of them until they substantially impact people. A major earthquake two centuries ago in the United States illustrates this reality.

The New Madrid Fault set off three earthquakes, centered in Arkansas, between December 1811 and February 1812. The earthquakes were so intense as to set off church bells on the East Coast over 1,000 miles away. The damages today would be

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[1] Center for Online Judaic Studies, Gilgamesh Epic: The Flood Story, http://cojs.org/gilgamesh_epic_the_flood_story/.

[2] Frank Lorey, The Flood of Noah and the Flood of Gilgamesh, http://www.icr.org/noah-flood-gilgamesh/.

[3] News: German and Dutch river flood benefits from more mum, less dad, Feb. 10, 2017, http://www.dutchwatersector.com/news-events/news/23386-german-and-dutch-river-flood-protection-benefits-from-more-mum-less-dad.html.

astronomical, but the vast area was sparsely populated without major structures in the early 1800's.[4]

Two natural disasters in the 17th Century during The Age of Enlightenment set the stage for discussing today's natural hazards risks both in Europe. The first, the Great London Flood of 1703, was of meteorological origin. The second, the Great Lisbon Earthquake of 1755, was of geological origin. The earthquake and its ensuing tsunami and firestorm affected large areas of Europe and North Africa as well as reaching the New World.

The Great Lisbon Earthquake of 1755

Rousseau recognized the development and population hazards reality after the Great Lisbon Earthquake. The earthquake, estimated to be 8.5 on the Richter scale,[5] was followed by a fire and tsunami. Much of the city was destroyed by this horrific trifecta of perils with an estimated 60,000 fatalities.[6] Most of the city's churches were destroyed on All Saints Day, giving rise to the claim that the earthquake was an Act of God.[7] Portugal's Prime Minister, the Marquis of Pombal, ordered a study of the tragedy, thus starting the field of seismology.

The great Voltaire[8] joined those who claimed it was an Act of God. The equally great Rousseau disagreed. Rousseau wrote to Voltaire" that it was hardly nature who assembled there twenty thousand houses with 6 or 7 stories. If the inhabitants of this large city had been more evenly dispersed and less densely housed, the losses would have been fewer or perhaps none at all."[9]

Natural disasters occur on built environments. Rousseau was prescient. Extreme natural hazards are only extreme when they involve great losses in lives or property.

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[4] USGS, Historic Earthquakes: New Madrid 1811-1812 Earthquakes, http://earthquake.usgs.gov/earthquakes/states/events/1811-1812.php.

[5] It is estimated to be a 8.5-9.1 on the MW scale (local magnitude scale) rather than the Richter Scale. Mark Molesky, This Gulf of Fire: The Destruction of Lisbon or Apocalypse in the Age of Science and Reason 6 (2015). The earthquake zone covered 5.8 million miles. Tremors were felt not only in Portugal, but also in Sweden, Norway, Germany, Netherlands, Ireland, Italy, Sardinia, Greenland, Cape Verde, the Azores, England and Venice. Id. at 111-115. It was especially damaging in Morocco and Tunisia in North Africa. Id. at 18-19. A tsunami hit Lisbon ½ hour after the earthquake. It also struck Spain, Morocco, Northeast Brazil, the West Indies, and Newfoundland. Waves reached Brittany, France, Brest, Cornwall, Plymouth, and Galway, Ireland. Id. at 143-4. See also, Edward Paice, Wrath of God: The Great Lisbon Earthquake of 1755 (2008) and Nicholas Shady, The Last Day: Wrath, Ruin & Reason in The Great Lisbon Earthquake of 1755 (2009).

[6] Marc-Andre Gutscher, What Caused the Great Lisbon Earthquake? Science, Aug. 27, 2004 at 1247. The earthquake damaged cities in Morocco with substantial loss of life in Algeria and Morocco and the tsunami reached Ireland, Cornwall in England and the Caribbean, 1755 The Great Lisbon Earthquake and Tsunami, Portugal, http://www.sms-tsunami-warning.com/pages/tsunami-portugal-1755.

[7] For a deconstruction of the Act of God defense in Tort Law, see Denis Binder, Act of God? Act of Man?: A Reappraisal of the Act of God Defense in Tort Law, 15 The Rev. of Litig. 1 (1996).

[8] Voltaire used the Great Lisbon Earthquake of 1755 for background in his famous book, Candide.

[9] Patrick Jacobe & Olivier Cadotte, Voltaire, Rousseau and the Lisbon Earthquake of 1755, https://prezi.com/w6kyixuyhllf/voltaire-rousseau-and-the-lisbon-earthquake-of-1755/.

The Great Lisbon Earthquake is an example of the global interconnectivity of nations when struck by the forces of nature. Natural forces do not respect artificial political boundaries.[10]

Large populations are concentrated in a relatively small land mass in Europe. Natural hazards are thereby likely to affect several nations. This table[11] of the populations, geographic sizes, and per capita densities of Northern Europe, Southern Europe, and Western Europe, compared to Saudi Arabia, show the great risk to Europe from natural disasters.

Area	Population	Square Miles (sm)	Per Capita Population
Northern Europe[12]	102,911,380	656,765	157/sm
Southern Europe[13]	152,163,420	500,005	304/sm
Western Europe[14]	191,303,129	418,959	458/sm
Saudi Arabia[15]	32,642,000	827,751	39/sm

We see in Northern, Southern, and Western Europe about three dozen countries, many small, on a relatively small land mass. Thus, a meteorological or geological hazard poses a great threat to a large number of countries.

By way of contrast, a similar threat in Russia, Canada, the United States, China, Brazil, Australia or India might be confined within the country's boundaries, although affecting many states or provinces within the country.

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[10] John Donne wrote in Devotions upon Emergent Occasions, Meditations XVII:

> "No man is an island entire of itself; every man
> is a piece of the continent, a part of the main;
> If a clod be washed away by the sea, Europe
> Is the less, as well as if a promontory were, as
> well as any manner of thy friends or of thine
> own were; any man's death diminishes me,
> because I am involved in mankind.
> And therefore never send to know for whom
> the bell tolls; it tolls for thee."

[11] The figures for the table come from the Worldometer, which updates the population figures on a continuous basis. I am using their fixed numbers from July 1, 2016.

[12] http://www.worldometers.info/world-population/northern-europe-population/. The countries included in Northern Europe are Estonia, Denmark, Finland, Iceland, Ireland, Latvia, Lithuania, Norway, Sweden, and the United Kingdom as well as the Channel Islands, Faroe Islands, and the Isle of Man.

[13] http://www.worldometers.info/world-population/southern-europe-population/. Southern Europe includes Albania, Andorra, Bosnia & Herzegovina, Croatia, Greece, Italy, Macedonia, Malta, Montenegro, Portugal, Serbia, Slovenia, and Spain, as well as Gibraltar, the Holy See and San Marino.

[14] http://www.worldometers.info/world-population/western-europe-population/. Western Europe consists of Austria, Belgium, France, Germany, Liechtenstein, Luxembourg, Monaco, the Netherlands, and Switzerland.

[15] http://www.worldometers.info/world-population/saudi-arabia-population/.

The Great Storm of 1703

The Great Storm of 1703[16] struck England five decades earlier than the Great Lisbon Earthquake of 1755. The storm was especially disastrous in England as it struck populated cities and harbors of South England. It also cut a 300 mile (500 km) wide belt of destruction across southern England, Wales, the southern North Sea, the Netherlands, North Germany, Denmark, and parts of France, Sweden, the Baltic Sea, Finland, and Russia.[17] Substantial property damage occurred throughout the impacted area. The storm may, or may not, have originated in the Caribbean and skipped past the states of Florida and Virginia.[18]

The storm struck with hurricane force winds on December 7, 1703 as the culmination of two weeks of steadily increasing stormy conditions. An estimated 8,000-15,000 perished including 6,000 sailors.[19] Hundreds of ships were sunk or damaged, including 13 British Navy warships in the English Channel. Millions of trees were leveled.

Daniel DeFoe collected stories from the survivors and witnesses. He published "The Storm" in 1704, which is claimed to be the first exercise of modern journalism.

The Great Storm of 1703 may have been extreme, but it is not an anomaly. The North Sea area is subject to storms with strong winds comparable to tropical hurricanes combined with storm surges during high tides. These storms are often called cyclones. The North Sea is a shallow, semi-enclosed shape, which can produce strong storm surges.[20] A storm surge during a spring tide is highly risky, with low lying areas along the coastline especially vulnerable.[21] Professor Lamb identified roughly 150 severe storms in the North Sea between 1509 and 1989.[22]

Professor Lamb developed a scale to measure the severity of the storms, looking at the greatest surface wind speeds, the greatest area covered at any stage by wind causing substantial damage, and the total duration of the damaging winds during the life of different storms.[23]

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[16] This article does not attempt to consider the effects of climate change. We should note though that the Great Strom of 1703 occurred during The Little Ice Age, which indicates that these storms can occur in cooler times and as well as warming times.

[17] Herbert lamb and Knud Frydendahl, Historical Storms of the North Sea, British Isles and Northwest Europe 59 (Cambridge University Press 1991), hereinafter referred to as "Lamb.".

[18] Id. at 62.

[19] BBC, Earth – In 1703 Britain was struck by its worst ever storm, http://www.bbc.com/earth/story/20170309-in-1703-britain-was-struck-by-possibly-its-worst-ever-storm?ocid=ww.social.link.email.l

[20] . Alexander Hall, The North Sea Flood of 1953, Environment and Society Portal, Arcadia 2013, No. 5, http://www.environmentandsociety.org/arcadia/north-sea-flood-1953.

[21] L. Fenoglio-Marc, et al, "Cyclone Xaver seen by geodetic observations," Geophysical Research Letters, Oct. 2015 at 9925.

[22] Lamb, supra n. 18 at 37-193.

[23] Id. at 7.

The 1703 storm only came in fifth on his scale with a rating of 9,000. The leading storm was a 1986 cyclone rating a 20,000, but it was centered in the North Atlantic off Greenland and thus outside the central region of his study.[24] The other storms rated ahead of the 1703 storm were in 1792 and 1825, both rated at 12,000, and 1694 at 10,000. By way of comparison, the devastating storm of 1953 was only rated a 6,000.[25]

Both the Great Storm of 1703 and the Great Lisbon Earthquake of 1755 occurred during the Age of Enlightenment and helped foster the scientific study of natural hazards. No longer could the rubric "Act of God" explain all natural phenomena.

The Foreseeable Unforeseeability of Extreme Natural Forces

Extreme natural hazards are seemingly paradoxical because they can be both foreseeable and unforeseeable simultaneously. For example, hydrologists map floodplains. Geologists identify seismic zones. Meteorologists identify, predict and track storms. However, the identification of general risks is but a preliminary step in predicting or controlling the specific risk, which is often outside human capability.

The general recognition of a potential extreme hazard does not necessarily allow for specific predictions for the timing, severity, and locale of impact. For example, the timing of an earthquake, its location, duration, velocity, magnitude, point of impact, and direction are still unpredictable. Tornadoes can be tracked with warnings often available for residents to seek shelter, but the loci of a tornado touchdown is unpredictable. Similarly, a hurricane heading towards the Atlantic or Gulf coasts of the United States has a wide arc within which to strike land.

In addition, natural risks remain despite the greatest efforts of engineers. Try as they might, humans often cannot prevent, deter, or divert extreme forces of nature, such as earthquakes, hurricanes, tornadoes, and volcanoes Indeed, human activity can create or enhance natural hazards.

The reality is that every major disaster, even of seemingly natural origin, will probably involve human fault; a combination of poor decisions and acts of negligence will often coalesce to magnify the impact and damages. Negligence may exist in planning, designing, construction, operations, maintenance or inspection. Deferred maintenance may be a problem with aging facilities and systems.

The Human Factor

Floods are a prime example of people adding to nature's risk. Humans build in and inhabit natural flood plains. They often channel rivers and streams in straight lines, increasing the velocity, whereas natural rivers and streams are often serpentine in shape. The destruction of open space increases runoff. Humans replace permeable

[24] Id. at 8.
[25] Id.

soils with asphalt roads, concrete foundations and parking lots, structures, tiles, and roofs, increasing the runoff headed downstream. Developing the littoral zone removes coastal wetlands, nature's sponge, which serves as a buffer zone against storms..

Two commentators recognized:

Though triggered by natural events such as floods and earthquakes, disasters are increasingly man-made. Some disasters (flood, drought, famine) are caused more by environmental and resource mismanagement rather by too much or too little rainfall. The impact of other disasters, which are triggered by acts of nature (earthquake, volcano, hurricane) are magnified by unwise human actions.[26]

Upstream flood control measures, such as dikes and levees, may protect the upstream area, but increase the pressure on weaker dikes and levees downstream. The European Union recognizes therefore that flood basin management requires river basin management plans[27] and coordination between member states.[28]

Stripping forests remove watershed protection, and again sends more waters downstream. Conversely building in woody areas changes the calculus of wildfires.

Construction methods can increase or decrease the risks during hurricanes. Maintenance, or the lack thereof, affects the ability of structures to withstand forces of nature.

In addition, complacency sets in. Maintenance expenditures are often cut in the absence of problems. The 'squeaky wheel" often drives infrastructure spending as a political and practical matter.

Preventative Measures to Reduce Flooding Risks

Common measures implemented to reduce, if not eliminate, flooding include dams and reservoirs, dikes, levees, and flood gates. Dams, dikes, and levees can provide protection within their design limits if properly designed, constructed, and maintained. Large flood detention basins and polders[29] are also helpful. Yet, Munich Re, the large reinsurance company, cautions us that 100% protection is impossible, short of zero human habitation. Dikes and levees can break. Uncontrolled

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[26] Anders Wijkman & Lloyd Timberlake, Natural Disasters: Acts of God or Acts of Man 6 (1984).
[27] Directive 2007/60/EC of the European Parliament and the Council of 23 October 2007 on the assessment and management of flood risks, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007L0060:EN:NOT.
[28] Id at 5
[29] Regionalism poses a problem though. Creating polders though has met with resistance in Germany by regional leaders who cannot justify their existence to reduce flooding in downstream areas. DW, Top Stories/Germany, German flood prevention still can't prevent floods, December 6, 2013, http://www.dw.com/en/german-flood-prevention-still-cant-prevent-floods/a-16876765.

construction in exposed areas, such as coastal areas and other low lying areas close to rivers and lakes, increases the risk.[30]

Structural solutions will often be unable to prevent or temper the extreme forces of nature. Structures have both design limits and design lives. For example, a facility designed for the 100 year event will be ineffective against the 200 or 500 year event. Structures wear out over time, quicker without proper maintenance.

Learning from Disasters

Smart societies and leaders learn from disasters. They try within the limits of technology to prevent or ameliorate the next one. For example, England realized after the disastrous flood of 1953 that it lacked a warning system to alert residents in advance and evacuate to safer grounds. Thus England established a storm tides warning system within the Met Office.[31]

Germany recognized after the 2002 flooding that its flood control measures were inadequate. It adopted an integrated flood risk management system pursuant to the German Flood Protection Act of 2005 and the European Floods Directive of 2007.

The German floods of 2013 were the most severe in 60 years, exceeding the 2002 storm. Losses were estimated at €6-8 billion compared to €11 billion in 2002.[32] The changes made included land use planning, preparedness measures, warning systems, coordinated disaster response, and targeted maintenance of flood-defense systems.[33]

The Netherlands built the Delta Works to reduce the risk to its low-lying lands. England created the Thames Barrier to protect London and surrounding areas from storm surges after the 1953 North Sea Flood. Both systems have been working to date.

We also have to recognize human fallibility in decision making. People can be remiss in their decisions. For example, emergency action plans may not be up to date or poorly implemented.

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[30] MunichRe, Flooding – There is no such thing as complete protection, May 7, 2013, https://www.munichre.com/topics-online/en/2013/07/flooding

[31] Met Office, 1953 east coast flood – 60 years on, http://www.metoffice.gov.uk/news/in-depth/1953-east-coast-flood.

[32] European Commission, Science for Environment Policy: Flood Risk Management Has Improved in Germany, # 469, Sept. 9, 2016, http://ec.europa.eu/environment/integretion/research/newsalert/pdf/flood_risk_management_improved_germany_469a2_en.pdf..

[33] Id., Annegret H. Thicken, et al, Review of the flood risk management system in Germany after the major flood in 2013, 21 Ecology and Society #2 at 51 (2016),http://dx.doi.org/10.5751?ES-08547-210251.

Earthquakes

The risks of earthquakes, volcanoes, and tsunamis are interrelated. Northern Europe is viewed as geologically stable with low seismic risks, but it is not though seismic free. One list of earthquakes in Northern Europe from 1375 to 1989 recognized over 5200 events, of which 28 were 5 and over on the Richter Scale and one measured 6.0.[34]

Britain experiences 200-300 earthquakes annually, but most are too small to notice.[35] However, a major exception was a 6.1 earthquake on June 3, 1931. The epicenter was 60 miles offshore at Dogger Bank in the North Sea. Extensive damage was reported in Britain[36]. Two other major North Sea centered quakes were the 1904 Oslofjord and a 1927 earthquake off Norway.[37] This study found 6 earthquakes of 6 or above and 28 of 5 or above between 1759 and 1977.[38]

More recently a 3.8 quake 93 miles out in the North Sea was felt along the Yorkshire coast.[39] A 5.2 earthquake was felt in Lincolnshire in 2008.[40]

Roermond in the Netherlands experienced a 5.3 earthquake on April 13, 1992. Researchers discovered that the Roer Valley of Belgium, Germany, and the Netherlands sits between two fault systems.[41]

The major seismic risks in Europe are centered in the Mediterranean and Iceland. Countries at risk include Bulgaria, Greece, Italy, Romania, Turkey, Recent decades have witnessed major earthquakes in Izmir, Turkey[42] and L'Aquila, Italy.

The Italian L'Aquila earthquake aftermath raised tremors throughout the scientific community. A series of minor earthquakes preceded a large earthquake, which killed 309 and left over 1,000 homeless. A public conference a week before the large quake issued assurances of safety. Six scientists and a public official were convicted in

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[34] T. Ahjosa & M.Uski, Earthquakes in northern Europe 1375-1389, 207 Tectonophysics 1, 14 Table 2 (992).

[35] BBC News, Science & Environment, Q&A: UK's small-scale earthquakes, http://www.bbc.com/news/science-environment-12112307.

[36] The earthquake was felt in Great Britain, Belgium, the Netherlands, Northern France, Germany, Norway, and Denmark. Frode Ringdal, Seismicity of the North Sea Area, in A. R. Ritsema & A. Gurpunar, Seismicity and Seismic Risk in the offshore North Sea Area (1982.

[37] The Oslofjord earthquake severely damaged a few buildings, but resulted in no fatalities. Id. at 68. The epicenter of the 1927 quake was off the west coast of Norway. The quake was felt over Scotland, East England, the Shetland Islands, and Norway south of Trondheim. Id. at 69. A list of North Sea earthquakes is available at earthquake track, http://earthquaketrack.com/r/north-sea/recent.

[38] Id. at 67, Table 2.

[39] Paul Johnson, How a North Sea earthquake caused mayhem on the east coast of Britain, Hull Daily News, January 4, 2017, http://www.hulldailymail.co.uk/how-a-north-sea-earthquake-caused-mayhem-on-east-coast-of-britain/story-30029534-detail/story.html.

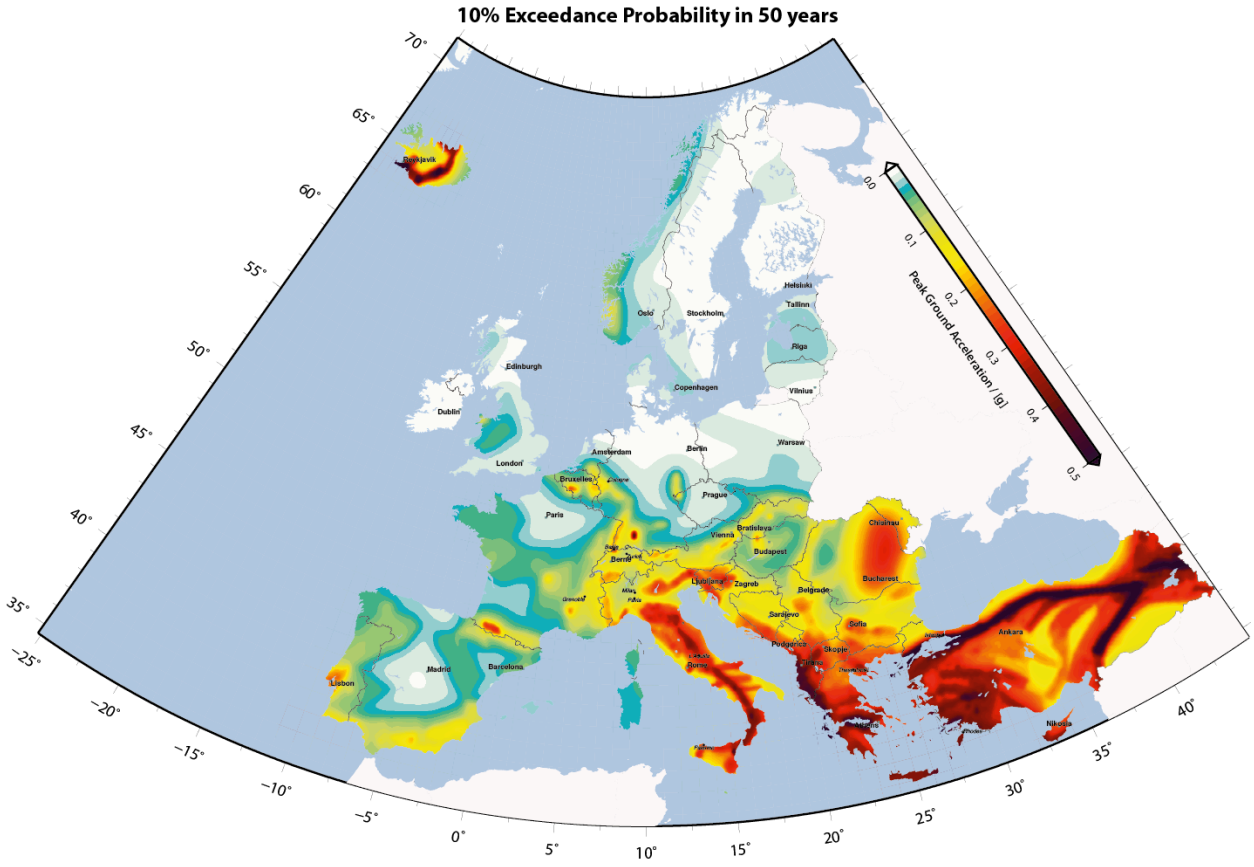
[40] Id.

[41] T. Camelbeeck & M. Meghraoui, Large earthquakes in Northern Europe more likely than once thought, 42 EOS Transactions American Geophysical Union 405 (October 15, 1966), https://www.researchgate.net/publication/248817999_Large_earthquakes_in_Northern_Europe_more_likely_than_once_thought

[42] The 7.6 1999 Ismit Earthquake killed over 17,000 can caused substantial property damage.

October 2013 of miscommunications of safety for issuing false assurances of safety The convictions of the scientists were overturned the next year, and later for the public official who said "there was no danger."

2013 European Seismic Hazards map (ESHM-13)



Volcanos

Volcanic eruptions are known risk in Iceland and southern Europe, especially around the Mediterranean. Mount Etna and Mount Vesuvius have become the lore of history.

Iceland experiences frequent volcanic eruptions. 39 eruptions were recorded in the 20th and 21st centuries.[43] The plume of ash from Iceland's Eyjafjallajukull volcanic eruption during April and May 2010 seriously interfered with air traffic for days.[44]

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[43] Eruptions in Iceland: 20th and 21st Century Eruptions in Iceland, https://www.extremeiceland.is/en/information/about-iceland/eruptions-in-iceland-since-1900.

[44] For example, the UK closed its airspace from April 15-20, 2010 because of the Eyjafjallajokull eruption. Microscopic particles of volcanic ash can be extremely dangerous to airplane engines. Eyjafgallajukull Eruption, Iceland/ April-May 2010, http://www.bgs.ac.uk/research/volcanoes/iceland_ash.htm.

Tsunamis

Tsunamis are not a common hazard for Northern Europe, but the Great Lisbon Earthquake of 1755 showed that a major earthquake off Portugal could send waves around the Atlantic Ocean and Mediterranean Sea. The tsunami risk is greater in the Mediterranean and Black Sea. Several European countries participate in the 39 country Intergovernmental Coordinating Group for Tsunami Early Warning and Mitigation System in the Northeastern Atlantic, the Mediterranean and Connected Seas.[45]

A total of 290 tsunamis have been recorded in the Norwegian Sea, North Sea, Northeastern Atlantic, Black Sea, and the Mediterranean.[46] 10% of the world's tsunamis have occurred in the Mediterranean.[47] The Mediterranean's tsunamis often do not provide a long warning time because of its semi-enclosed basin and short travel times of the waves before they strike shore.[48]

Flooding

Erika Boustad in Scientific American posited extreme floods may be the new norm.[49] History tells us that severe flooding, often in coastal areas, has been the greatest natural threat to Europe, which now seems to be experiencing severe flooding annually.[50]

The cliché is that "You can't control nature." The major risk that has seemingly been a constant through the centuries is flooding, both from coastal storms and excessive precipitation inland. Some of the coastal storms have winds strong enough to constitute a "cyclone." Heavy precipitation can also come from the Mediterranean.

A look at some of the 20th and 21st Century floods will illustrate the existential threat to Northern Europe from floods from costal storms, and reaffirm the thesis that the storms do not respect political boundaries.[51]

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[45] The ICG/NEAMTWS was established by the Inter-governmental Oceanographic Commission of UNESCO in June 2005. Resolution XXIII.14

[46] Id. at 24.

[47] Intergovernmental Oceanography Commission, 10 Years of the North-eastern Atlantic, the Mediterranean and Connected Seas Tsunami Warning and Mitigation System: Accomplishments and Challenges for the Next Tsunami, IOC/INF -1340 at 22 (Feb. 2017).

[48] Id. at 8.

[49] Erika Boustad, Natural Disasters: Extreme Floods May be the New Norm, Scientific American, https://www.scientificamerican.com/article/extreme-floods-may-be-the-new-normal/.

[50] See e.g. German Committee for Disaster reduction (DKW), Severe Storms over Europe: A Cross-Border Perspective of Disaster Reduction. Second International Workshop, March 26-26, 2007.

[51] I hate to cite Wikipedia, but it provides a list of notable recorded floods in Europe, https://en.wikipedia.org/wiki/List_of_floods_in_Europe.

1953

The North Sea Flood of January 31-February 1, 1953 was especially devastating Europe recovering from World War II.[52] High spring tides coupled with a deep Atlantic depression and strong northerly gales led to storm surges. The lack of warning systems added to the casualty list in England with 307 deaths and 19 in Scotland as well as 230 at sea. Over 1,600 km of coastlines were damaged and sea walls were breached in England. Dikes failed in the Netherlands. Water levels rose up to 18.4' above mean sea level.[53]

32,000 were evacuated in England and 160,000 acres inundated with sea water. Wind gusts reached 127mph at Costa Hill, Orkney.[54] Winds were recorded at up to 120mph in England and Wales. 24,000 properties were damaged.[55]

The Netherlands was struck harder. 1,836 deaths occurred in the storm. 340,000 acres were flooded, 100,000 evacuated, and 47,300 buildings damaged.[56]

The Great Storm of 1987

The November 15-16, 1987 storm was considered the worst since 1703 as it struck Northern France and Southern England especially hard. The storm cut a swath of damage from Norway to Portugal and Spain. Cyclone force winds reached 135mph at Pointe Do Roc, Brittany, France. One gust at Gorleston, Norfolk, England was recorded at 122mph. The wind speeds between North London and Great Yarmouth had a return period of 200 years.[57]

England incurred £1.5 billion in damages with18 lives lost and 18 million trees leveled.[58] France lost 10 million trees. Norway experienced 4" of rain in 48 hours with flooding in Oslo.

2002

Record precipitation in Germany in August 2002 caused over €11 billion in damages.[59] The storm's impact revealed weaknesses in Germany's flood

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[52] For example, the sea defenses were in a dilapidated condition after the war. Alexander Hall, The North Sea Flood of 1953, Environment and Society Portal, Arcadia 2013, No. 5, http://www.environmentandsociety.org/arcadia/north-sea-flood-1953.

[53] The North Sea Storm of 2013, Arcadia 2013, No. 3, http://www.environmental society.org/arcadia/nortg-sea-flood-1953

[54] Met Office, 1953 East Coast Flood – 60 Years On, http://www.metoffice.gov.uk/news/in-depth/1953-east-coast-flood.

[55] Environmental & Societal Portal, The North Sea Flood of 1953, http://www.environmentandsociet.org/arcadia/north-sea-flood-1953.

[56] Id.

[57] Risk Management Systems, RMS Special Report, The Great Storm of 1987: 20-Year Retrospective (2007), http://forms2.rms.com/rs/729-DJX-565/images/ws_1987_great_storm_20_retrospective.pdf.

[58] Daily Mail, The Great Storm of 1987: How the 'hurricane' claimed 18 lives, flattened 15million trees and caused damage costing £1.5billion, http://www.dailymail.co.uk/news/article-2478167/Great-Storm-1987-claimed-18-lives-flattened-15m-trees-caused-1-5bn-damage.html.

management, including a poor warning system, poor structural maintenance, a lack of risk awareness, and failure to understand response efforts.[60]

Cyclone Xynthia 2010

Cyclone Xynthia was a massive windstorm which struck western Europe between February 27 and March 1, 2010. The death toll was 47 with damages about €2.5 billion. It caused damage in Portugal, Spain, Germany, and England, but hit the France coast especially hard. 29 died in La Faute-sur-mer in homes built since 1980 in a "red zone" meant to bar development. 22 of the victims were over 60, while hundreds of homes were flooded.[61] The mayor was sentenced to 4 years; the officer in charge of building permits received 2 years while her son in charge of ensuring and monitoring the safety of the seawall was sentenced to 18 months.[62] They had permitted development in the Red Zone while failing to ensure the safety of the coastal zone. The storm was a natural force, but building homes in the restricted area "protected" by poorly located, fragile sea walls was the human cause that magnified damages.

2013

Widespread flooding occurred in Central Europe in June 2013. Germany. Austria, the Czech Republic, Slovakia, Hungary, Croatia, Serbia, and Poland were hit hard.[63] The Danube River in Budapest hit an historic high of 29'. Flood waters rose to 24' in Magdeburg, Saxony-Anhalt. Parts of Warsaw flooded.[64] The Danube River is joined up by two tributaries, the Inn and the IIz in Passau, Germany. Passau recorded its highest flood level since 1501.[65]

Cyclone Xaver: The North Sea Flood of 2013

Cyclone Xaver struck Northern Europe on December 4-10. 2013,[66] hitting Belgium, Denmark, the Faroe Islands, Germany, Ireland, Lithuania, the Isle of Man, Netherlands, Norway, Poland, Scotland, Sweden, and the United Kingdom. The storm was characterized by hurricane force gusts, torrential rains, and storm surges.

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[59] Science for Environmental Policy, Flood risk management has improved in Germany #469 (September 9, 2016).
[60] Annegret H. Thicken, et al, Review of the flood risk management system in Germany after the major flood in 2013, 21 Ecology and Society #2 at 51 (2016),http://dx.doi.org/10.5751?ES-08547-210251.
[61] Eliasbetta Genovese, et al, Disaster Risk Management and Territorial Governance: Lessons from Xynthia Storm in France 3 (FIG Working Week 2012).
[62] Visiting France, French mayor jailed for four years over 2010 storm deaths, http://en.rfi.fr/visiting-france/20141212-france-mayor-jailed-four-years-xynthia-storm.
[63] Annegret H. Thicken, et al, Review of the flood risk management system in Germany after the major flood in 2013, 21 Ecology and Society #2 at 51 (2016),http://dx.doi.org/10.5751?ES-08547-210251.
[64] BBC, Thousands flee flood-hit parts of Germany and Hungary, June 10, 2013, http://www.bbc.com/news/world-europe-22835154.
[65] Jim Andrews, Historic Flooding in Central Europe, AccuWeather (June 9, 2013), http://www.accuweather.com/en/weather-news/historic-flooding-in-central-e/13854991.
[66] It was named "Bodic" in Denmark, Ksawery in Poland, and "Swen" in Sweden.

Some storm surges exceeded those of 1953. Sea levels rose 19" in Hull and 15" in Dover.[67] Wind gusts reached 142mph in Scotland and up to 98mph on the Germany-Denmark border. 1,400 homes were flooded in England and Wales. 100,000 homes in Scotland and over 6,500 in Northern Ireland lost power.

Rail service was cancelled in all of Scotland and shut down in 1/3 of Germany. Waves up to six meters high struck Hamburg, the second highest surge since 1825.[68] Two towns in Denmark, Frederikssund and Frederiksvaerk, were evacuated.

The Thames Barriers were closed for two days, preventing the flooding of London. The Netherlands was also protected by the Eastern Scheldt barrier created since 1953.[69]

2014

The Balkans in 2014 were struck by their worst flooding in 120 years.[70]

2016

A series of severe convective storms struck Europe in May and June 2016. Fatalities occurred in Belgium, France, Germany, and Romania.[71] Germany experienced severe thunder storms for 15 days from May 26-June 9. Flash floods, hail, and tornadoes accompanied the severe thunderstorms.[72] Rainfall at one point in Gundelsheim, Germany was 122mm (4.8') within 24 hours.[73]

Northeast France experienced up to six full weeks of rain within 24 hours.[74] The Seine River in Paris reached its highest levels since 1982. The 1982 flood level reached 20', which was lower than the record 26.2 inches in 1910.[75] The Louvre and

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[67] A Level Geography, East Coast Flooding in UK – 5th December 2013, http://www.alevelgeography.com/coastal-flooding.

[68] Alert Worldwide, December 12, 2013, Extratropical Cyclone Xaver, http://alert.air-worldwide.com/EventSummary.aspx?e=726&tp=72&c=1, and http://alert.air-worldwide.com/EventSummary.aspx?e=65&c=1.

[69] Id.

[70] Alan Taylor, Balkans Struck by Worst Flooding in 120 Years, May 20, 2014, https://www.theatlantic.com/photo/2014/05/balkans-struck-by-worst-flooding-in-120-years/100739/.

[71] https://wwa.climatecentral.org/analyses/european-rainstorms-may-2016/

[72] David piper, et al, Exceptional sequence of severe thunderstorms and related flash floods in May and June 2016 in Germany, part I: Metrological background, 16 Natural Hazards and Earth System Sciences 2835 – 2850 (2016), http://www.nat-hazards-earth-syst-sci.net/16/2835/2016/nhess-16-2835-2016-discussion.html.

[73] Id.

[74] Tom Moore, Here's What Caused the Deadly Floods in Germany and France, The Weather Channel (June 1, 2016), https://weather.com/news/international/news/europe-flood-excessive-rain-blocking-pattern-germany-france.

[75] Lisa Blaise & Benoit Morenne, In Paris, the Seine Rises to Highest Level Since 1982, N. Y. Times, June 3, 2016, https://www.nytimes.com/2016/06/04/world/europe/paris-flooding-seine-louvre.html?_R=1.

Musee d'Orsay were closed to move works of art to safety.[76] Over 20,000 were evacuated in France and around 19,000 homes lost power.[77]

2017

Denmark, Germany, and Poland were hit hard by a storm in January 4,2017 with severe flooding. Sea levels reached 1.75 meters above normal. The Danish Meteorology Institute reported that the flooding was a 100 year flood in Wismar, Germany. Parts of Germany experienced the strongest storm surge since 2006.[78]

The Czech Republic, and Hungary experienced major flooding later in January along the Danube. Flooding hit an historic high in Budapest peaking at 8.49 meters, but the protective structures held.[79]

Conclusion

Let us recognize that extreme forces of nature are the norm - not a new normal. Extreme hazards defy human control. "Extreme hazards" by itself is a misnomer. Nature is nature. We are learning at great cost in lives, property, and dollars the limits of our ability to control geological and meteorological risks. Humans often cannot prevent or deter the extreme, unavoidable forces of nature, such as earthquakes, hurricanes, tornadoes, tsunamis, volcanoes, ice storms, and wildfires as well as more common risks such as flooding.

Flooding is consistently the greatest natural hazard in Europe. The flooding is usually directly, or indirectly, from coastal storms, often containing hurricane force winds. Even inland flooding will often be caused by coastal storms which passed over the coastal zone and moved inland.

Forces of nature though do not observe artificial political boundaries. Thus a tsunami unleased by an earthquake striking Lisbon can flow across the Atlantic to the Americas and then bounce back to Northern Europe. A North Sea storm can move on from the coast into Central Europe.

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[76] Aurelien Breeden, From Paris to Bavaria: Heavy Rains Cause Deadly Floods, New York Times, June 2, 2016. https://www.nytimes.com/2016/06/03/world/europe/france-germany-floods-rain.html?_r=0.

[77] Angelique Chrisafis, Paris Floods: There's something terrifying about it, The Guardian, June 4, 2016, https://www.theguardian.com/world/2016/jun/03/paris-river-seine-floods.

[78] Richard Davies, Denmark, Germany and Poland – Storm Surge causes Coastal Flooding, http://floodlist.com/europe/denmark-germany-poland-storm-surge-flood-january-2017.

[79] Daily Mail, Flooding of Europe Continues, http://www.dailymail.co.uk/news/article-134033/Flooding-Europe-continues.html