Foresight Drivers & Signals Library

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Overview

Library Purpose

This library aims to provide a thorough list of examples that demonstrate the important ways in which the world is changing and why it matters. This document is intended to assist emergency managers as they define and assess current conditions in their organizational and operational contexts. Further, this library should serve as a useful complement to the integration of other strategic foresight methods and tools.

FEMA's Strategic Foresight 2050 initiative employed the Social, Technological, Economic, Environmental, and Political factor (STEEP) framework and this library is organized accordingly. The STEEP framework is one of many tools that can guide a systematic assessment of trends, adding rigor to the scanning phase of any strategic foresight process.

Signals and Drivers of Change

In the realm of emergency management, being prepared for the future requires more than just reacting to current challenges—it demands a keen understanding of the subtle cues and powerful forces that shape the evolving landscape. Foresight identifies *signals* and *drivers* as tools for perceiving, anticipating, and interpreting the dynamic course of change.

Signals

Signals are early whispers of change—nuanced indicators that precede major shifts in the emergency management landscape. They do not significantly impact the present, but they hold potential for monumentally shifting the future. They may be an emerging trend, a behavioral shift, or a technological advance. Monitoring these cues provides an early warning system, enabling proactive response and informed decision-making.

Drivers

Drivers are the forces that propel and shape change in emergency management. These can be social, technological, economic, environmental, or political factors that exert influence on the direction and intensity of developments. Understanding these drivers is pivotal for crafting resilient strategies that stand robust in the face of evolving challenges.

Environmental Drivers of Change

Increasing frequency and intensity of heat waves, drought, and wildfires

As precipitation patterns change, droughts will become more frequent, lasting, and severe. Periods of warmer, drier weather will lead to longer and more active fire seasons. These phenomena may lead to positive feedback loops that increase the rapidity and/or intensity of change.

IMPLICATIONS:

- Increasing heat island impacts and higher overnight low temperatures will become an increasing public health crisis.[1] Demands on hospitals and cooling stations could become unmanageable, especially when compounded with other impacts like power outages.
- There may be more wildfires or droughts requiring resources from the emergency management enterprise. These resources could include the need for improved building codes (and adherence to them), greater community resilience, and/or longer-term complex responses.

SIGNALS:

- As of 2024, major U.S. cities experience on average six heatwaves per year, which is 50% more than in the 1990s. Heatwave seasons are lasting nearly twice as long compared to the 1990s.[2] In general, extreme heat events are expanding in frequency and geographic scale across the U.S.[3]
- A 1°C rise in average temperature is expected to increase the median burned area in some Western U.S. forests by up to 600%.[4]

[1] "Learn About Heat Islands." 2023. U.S. EPA (EPA.gov)

[2] "Climate Change Indicators: Heat Waves." 2023. U.S. EPA (EPA.gov).

[3] "Climate Change 2023: Synthesis Report Summary for Policymakers." 2023. IPCC (IPCC.ch).

[4] "Climate Change Could Increase Risk of Wildfires 50% by Century's End." 2022. The New York Times (NYtimes.com).

Increasing regional weather variability and an expanded range of extreme conditions

Rapid transitions between extreme wet conditions in winter and extreme dry conditions in summer (called the "drought-to-deluge" cycle) are expected across the country. These cascading impacts will create additional challenges for emergency managers.

IMPLICATIONS:

- Infrastructure and other critical systems will be vulnerable to fluctuating conditions. Communities will experience more varied and frequent impacts including power outages, contaminated water systems, and damaged properties.
- Preparedness for divergent disaster conditions will require increasing resources. For example, communities will face competing priorities as they implement flood control measures while storing water in anticipation of water shortages due to either broken infrastructure or drought conditions.
- The sheer geographic spread of disaster may tax available resources, making response and recovery even more challenging.

SIGNALS:

- Due to enduring drought conditions, the 2022 Calf Canyon/Hermits Peak fire broke records in its geographic span. Subsequent monsoon rains falling on burn scars resulted in catastrophic flooding in the area.[5], [6]
- May 2019 was the wettest month on record, with 82.3% of the U.S. experiencing abnormally high precipitation. The year 2019 also consisted of the second wettest 12 months in U.S. history.[7]

[5] "New Mexico blaze is now largest wildfire in state history." 2022. The Washington Post (Washingtonpost.com).

[6] "2022 Hydrology Summary." 2022. National Weather Service (Weather.gov).

[7] "2019 was the 2nd Wettest Year on Record for the U.S." 2020. (noaa.gov)

Emerging novel characteristics of tropical cyclones, including more rapid intensification

Global temperature increases are warming oceans and shifting the jet stream further north. Warmer oceans and lower vertical wind shear will lead to increasingly erratic tropical cyclones that intensify rapidly and move slowly.

IMPLICATIONS:

- More rapid tropical cyclone intensification will lead to less warning time for evacuations. Emergency managers will need to contend with evacuations occurring over more compressed timescales.
- Slower and more erratic hurricane movement after landfall can lead to more localized or extreme impacts that exceed typical probabilities used for infrastructure design. These impacts could lead to higher levels of destruction, intensifying response and recovery needs.

SIGNALS:

- Grey swan tropical cyclones have begun to emerge.[8] Several recent hurricanes, such as Harvey, Irma, and Maria, have intensified or changed tracks rapidly enough that populations were less prepared than they might otherwise have been.[9]
- In August 2023, a tropical storm watch was issued for the first time in California due to an unusual West Coast hurricane.[10]
- Hurricane Harvey (2017) stalled and left 60 inches of rain over locations in Texas, exceeding reservoir capacities.[11]
- Cyclone Daniel, a "Medicane" (Mediterranean cyclone), caused dam failures in Libya, killing over 11,000 in floods, the deadliest Mediterranean storm in history.[12]

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8 "'Grey Swan' Cyclones Predicted to be More Frequent and Intense." 2015. MIT News (MIT.edu)

9 "Chapter 11: Weather and Climate Extreme Events in a Changing Climate."2021. IPCC (IPCC.ch).

10 "'Widespread flooding' expected as intense Hilary pounds Southern California." 2023. Los Angeles Times (LAtimes.com).

11 "How climate change is rapidly fueling super hurricanes." 2022. The Washington Post (Washingtonpost.com).

12 "'An unimaginable scene': Survivors describe Libya floods." 2023. BBC News (BBC.com).

Shifting of seasonal severe weather conditions and more intense thunderstorms

Global climate change is driving differences in storm patterns across the U.S. Supercell thunderstorms will occur more often in the eastern and southeastern U.S. and their frequency outside of the traditional storm season will also increase. More supercells and tornadoes will happen in late winter and early spring months.

IMPLICATIONS:

- More $1 billion storms are occurring, creating increased stress on the emergency management community's workforce and resources as these events continue to co-occur, compound, and cascade.
- Building codes and standards adoption areas will need to shift their geographic extents to align with expanding regions of risk.

SIGNALS:

- While the annual frequency of tornadoes has remained steady, their spatial distribution has been shifting from the Great Plains to the South and Midwest.[13]
- Derechos in densely populated parts of the country have delivered abnormal severe weather, caused extensive property damage, and yielded power outages to millions of people lasting several days or more.[14,15,16]
- Tornadoes in the southeast U.S. are increasingly frequent. Storms in this region tend to occur overnight and are in locations with a high number of mobile home communities.[17] The Mississippi tornado outbreak in March 2023 illustrates the devastating impact resulting from these events.[18,19]

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[13] "Here's what we know about how climate change is fueling tornadoes." 2023. The Washington Post (Washingtonpost.com).

[14] "Derecho: Behind Washington, D.C.'s destructive thunderstorm outbreak." 2012. The Washington Post (Washingtonpost.com).

[15] "Northeast Storms Spawn Nine Tornadoes, Kill Five and Knock Out Power to Thousands." 2018. The Weather Channel.

[16] "Derecho leaves area with damage, power outages." 2023. NPR Illinois (Nprillinois.org).

[17] "Annual and seasonal tornado trends in the contiguous United States and its regions." 2018. International Journal of Climatology (Wiley.com).

[18] "The Future of Supercells in the United States." 2023. Bulletin of the American Meteorological Society (Ametsoc.org).

Thawing and decreasing range of permafrost

Thawing and decreasing permafrost can cause the ground to change and shift, destroying local infrastructure. Melting permafrost may also alter the flora and fauna prevalence in a region, which will impact traditional activities, or lead to landscape-scale changes that shift the likelihood of wildfires.

IMPLICATIONS:

- Increasing impacts in remote areas and Indigenous communities, particularly in Alaska, include collapsing roads, building, and pipes. Furthermore, traditional fishing grounds, subsistence resources, and culturally significant landscapes may be compromised. To support resilience, emergency managers will need to be increasingly adaptive and responsive to community priorities.

- Increasing infrastructure failure – whether from shifting ground or coastal erosion – will continue to force communities to relocate. Emergency managers will need to facilitate interagency collaboration to understand risks, develop plans, and establish support for communities relocating.

SIGNALS:

- Temperatures are rising two to three times more quickly at the poles compared to the rest of the world. Thawing permafrost threatens infrastructure across North America, including road networks and pipelines.[20]

- Alaskan communities facing unstable grounds and collapsing infrastructure are being forced to relocate to new areas (such as Alaskan natives living in the City of Nunapitchuk).[21]

[20] "Permafrost carbon emissions in a changing Arctic." 2022. Nature Reviews Earth & Environment (Nature.com).

[21] "Nunapitchuk prepares to relocate as thawing permafrost threatens livelihoods." 2023. Alaska's News Source (Alaskasnewssource.com).

Rising sea levels

Higher average global temperatures, especially in polar regions, will accelerate sea level rise. The impacts may not be evenly distributed across locations due to differential circulation patterns (such as the warm Loop Current entering the Gulf of Mexico from the Caribbean Sea) and may be compounded by subsidence in coastal areas (e.g., Louisiana or South Carolina).

IMPLICATIONS:

- Rising sea levels will cause greater erosion, saline intrusion, and more regular coastal flooding. Risk assessments will become increasingly important and preparedness measures, including evacuation plans, will need to be in place.
- Coupled with storm events, storm surge and coastal flooding impacts may lead to greater damage or destroyed infrastructure, requiring a greater demand for emergency response and recovery.
- Water, sewer, transportation, and communication systems could all be affected, and barrier islands and coastal marshes protecting the coastline could be ruined.
- Emergency managers will play a growing role in capacity building in communities to improve resilience to rising sea level impacts to maintain or increase their long-term viability.

SIGNALS:

- The combination of sea-level rise in the Gulf of Mexico and around Florida have led to higher water levels associated with hurricanes and storm surge (such as Hurricane Ian in 2023).[22]
- High tide flooding has more than doubled throughout Gulf and Southeast coastal areas since 2000, in part because of subsidence and over pumping of groundwater. Impacts include transportation disruptions and corroding infrastructure.[23]

[22] "Seas have drastically risen along southern U.S. coast in past decade." 2023. The Washington Post (Washingtonpost.com).

[23] "New Data Details the Risk of Sea-Level Rise for U.S. Coastal Cities." 2024. The New York Times (NYTimes.com).

Increasing potential for pandemics and other vector-borne illnesses

Climate change driven habitat shift and expanding development tied to continued globalization will increase the frequency of vector-borne illness and large-scale pandemics.

IMPLICATIONS:

- Emergency managers will need to manage increasingly frequent and concurrent events, requiring more resources and staff capacity.
- During a pandemic, standard evacuation procedures or shelters may be unsafe. Emergency managers will need to develop plans for novel cascading impacts.

SIGNALS:

- Historical trends on global pandemics show that outbreaks are increasing in frequency. A study from 2021 estimates that the likelihood of a COVID-19-level pandemic is about 2% per year.[24]
- During the COVID-19 Public Health Emergency, FEMA had to reconsider typical sheltering facilities with large open spaces, such as schools, churches, community centers for disaster survivors who are unable to return to their pre-incident or new housing option. In future disasters, FEMA may have to adopt additional strategies to house survivors in a manner that provides a level of separation between individuals / households and does not increase the risk of exposure to or further transmission of vector-borne illnesses.[25]
- Climate change is already shifting the geographic range of disease-carrying ticks, mosquitoes, and rodents.[26]

[24] "Intensity and frequency of extreme novel epidemics." 2021. PNAS (PNAS.org).

[25] "Potential FEMA Emergency Sheltering Options During the COVID-19 Pandemic." 2020. Congressional Research Service (Congress.gov)

[26] Climate change increases cross-species viral transmission risk." 2022. Nature (Nature.org).

Societal Drivers of Change

Aging population

The nation's 65-and-older population is projected to nearly double in size in coming decades, from 49 million in 2016 to 95 million people in 2060. As a result, the share of people aged 65 and older will grow from about 15% in 2016 to nearly a quarter of the population in 2060.

IMPLICATIONS:

- An older population may have greater or more complex needs during evacuations and recovery processes. Healthcare systems need to be prepared to serve these individuals should a disaster occur.
- Accessibility needs will become more widespread as an increasing percentage of the population navigates age-related mobility challenges. Emergency managers will need to provide high levels of support, particularly during evacuations.
- Emergency managers will need to align with preferred communication formats for sharing information with older groups, who may not have the same access to technologies or social circles as younger individuals.

SIGNALS:

- While immigration helps drive overall population growth, U.S. states are reporting that fertility rates are dropping,[27] which contributes to the increasing relative size of the elderly population.
- Projections indicate that, by 2030, 1 in 5 Americans will be 65 or older. By 2060, almost 1 in 4 Americans will be 65 or older.[28]
- Between 1980 and 2019, centenarians in the U.S. tripled from 32,194 in 1980 to 100,322 in 2019.[29]

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[27] "The Long-Term Decline in Fertility—and What It Means for State Budgets." 2022. The Pew Charitable Trusts (Pewtrusts.org).

[28] "Demographic Turning Points for the United Sates: Population Projections for 2020 to 2060." 2020. U.S. Census (Census.gov).

[29] "2020 Profile of Older Americans." 2021. Administration of Community Living (acl.gov).

Increasing overall population and greater diversity

The U.S. is projected to grow by nearly 79 million people in the next four decades, from about 326 million to 404 million between 2017 and 2060. This growth is tied to increasing birth and immigration.

As the country gets more racially and ethnically diverse, increasing heterogeneity in communities and workplaces may promote more widespread valuing of a diversity of decision-making practices and ways of knowing, including Indigenous Knowledge. There may also be a greater focus on acknowledging and restoring past injustices.

IMPLICATIONS:

- With continued immigration and internal migration, the diversity of the workforce will increase. This will require new forms of equity analysis, inclusionary policies, and accessibility in leadership and the workplace. Emergency managers may be called upon to incorporate Indigenous Knowledge as well as knowledge from other cultural communities.
- As the population grows, more people will be exposed to hazards and emergency situations. Emergency management capacity and resources will need to adapt accordingly.
- Growing immigration rates will result in increasing language diversity and limited English proficiency. Emergency managers will need to overcome corresponding communication barriers and devote more resources to translation or similar outreach efforts.

SIGNALS:

- Fewer deaths and rebounding immigration in 2023 resulted in the largest U.S. population gain since 2018.[30]
- Census data finds that, between 2010 and 2020, racial and ethnic diversity increased in the U.S.[31]
- In December 2021, the federal government published guidance on valuing and including Indigenous Knowledge in decision-making.[32]

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[30] U.S. Population Trends Return to Pre-Pandemic Norms. 2023. U.S. Census (census.gov)

[31] "2020 U.S. Population More Racially, Ethnically Diverse Than in 2010." 2021. U.S. Census (Census.gov).

[32] "What is "Indigenous Knowledge" And Why Does It Matter? Integrating Ancestral Wisdom and Approaches into Federal Decision-Making." 2022. The White House (Whitehouse.gov).

Declining social connectivity and trust in institutions

As media consumption grows increasingly tied to political beliefs, there are fewer universally trusted news sources and growing mistrust of government sources. At the same time, people have fewer close confidants and trusted community members.

IMPLICATIONS:

- During a disaster, there are fewer people getting checked-in on by friends or neighbors, and fewer people that those in trouble can call for help.
- As distrust in government grows, official governmental avenues of risk communication may be less successful at convincing people to act.

SIGNALS:

- 12% of Americans say that they have no close friends.[33]
- In 2023, a survey on public trust in the federal government found the lowest beliefs in 70 years that "the government in Washington" does what is right. [34]
- A survey that asked about trust in specific sources found that Democrats trust news sources that Republicans are skeptical of and vice versa.[35]

[33] "The State of American Friendship: Change, Challenges, and Loss." 2021. AEI Survey Center on American Life (Americansurveycenter.org).

[34] "Public Trust in Government: 1958-2023." 2023. Pew Research Center (Pewresearch.org)

[35] "U.S. Media Polarization and the 2020 Election: A Nation Divided." 2020. Pew Research Center (Pewresearch.org).

Increasing concerns about well-being

The increasing cadence of emergency management and a growing societal focus on wellbeing are shining light on employee mental health. Recent research has emphasized mental health and the importance of recovery from trauma, which has filtered into policymaking.

IMPLICATIONS:

- It may become more difficult to retain emergency managers because the working conditions are emotionally and physically difficult.
- Disaster response may increasingly incorporate processes that help victims process trauma.

SIGNALS:

- In March 2024, FEMA was functioning at 65% of its capacity because of a lack of staff. This can lead to burnout, attrition, and diminished training opportunities.[36]
- The Department of Health and Human Services has as one of its Healthy People 2030 goals as improving emergency preparedness and response by building community resilience, which includes training; communicating with empathy, accountability, and commitment; overall threat awareness; and participating in the community.[37]

[36] "Lawmakers debate the role of an overworked and under-resourced FEMA. 2024. Government Executive (Govexec.com).

[37] "Emergency Preparedness." 2020. Department of Health and Human Services (Health.gov).

Technological Drivers of Change

Increasing use of uncrewed vehicles/vessels and other advanced robotics

More sensors will provide data for locations that are otherwise inaccessible or may be able to cover wide swatches of land, air, or water. To avoid putting humans in dangerous conditions, uncrewed vehicles/vessels may be increasingly leveraged to assess damage, gather data, or provide supplies after or during a disaster.

IMPLICATIONS:

- Diverse teams of semi-autonomous robots may become an increasingly critical tool for search-and-rescue operations.
- Uncrewed vehicles could provide initial assessments of disaster zones and provide initial resources to those isolated by disasters.
- Because of improved robotic and autonomous technologies, people may choose to live farther away from population centers, become more car dependent, or rely more on transportation systems that are integrated. These shifting populations and dependencies may complicate evacuations.

SIGNALS:

- Remote sensing can now provide a map of the extent of damage from hurricanes.[38]
- Drones were used to establish a network for cellphones in China immediately after a flood.[39]
- After a parking garage collapsed in New York, robotic dogs were sent in to avoid putting first responders in further danger.[40]

[38] "Remote Sensing Enables Assessing Hurricane Damage." 2013. American Geosciences Institute (Americangeosciences.org).

[39] "China Deploys Drone to Restore Communications During Flood Disaster." 2021. DRONELIFE (Dronelife.com).

[40] "Why The Future of Disaster Relief Will Rely on Robots." 2023. Inverse.com (Inverse.com).

Increasing frequency and criticality of cyberattacks

Centralized networks are increasingly prone to cyberattacks as control systems become more integrated. These cyberattacks could occur during natural disasters, compounding the impacts.

IMPLICATIONS:

- Emergency managers need to be prepared for a prolonged loss of power or a loss of access to their online resources during natural disasters.
- Increasing reliance on digital software systems and communication networks compounds the impact of cyber degradation. Decreasing institutional knowledge around analog emergency management processes will exacerbate consequences when electronic options fail.
- Critical systems will need to have more sophisticated and up-to-date defenses against cyberattacks while considering that natural disasters create vulnerabilities that adversarial actors will continue to use to their advantage.

SIGNALS:

- Ransomware and other forms of cyberattacks are an increasing globalized threat[41] that have hit local governments[42] and a variety of industries, ranging from energy (e.g., Colonial Pipeline[43]) to healthcare.[44]
- Centralized data handling or commonly used software components (e.g., SolarWinds[45], Log4j[46]) can lead to supply chain attacks that disrupt the operations across government and industry that are not the primary target. This will require a concerted effort between public and private sectors over time for response and recovery.

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41 "2021 Trends Show Increased Globalized Threat of Ransomware." 2022. CISA (CISA.gov).

42 "Ransomware completely shuts down Ohio town government." 2017. TechCrunch (Techcrunch.com).

43 "The Attack on Colonial Pipeline: What We've Learned & What We've Done Over the Past Two Years." 2023. CISA (CISA.gov).

44 "Why Hospitals Are the Perfect Targets for Ransomware." 2016. WIRED (Wired.com)

45 "SolarWinds Cyberattack Demands Significant Federal and Private-Sector Response." 2021. U.S. GAO (GAO.gov).

46 "Apache Log4j Vulnerability Guidance." 2022. CISA (CISA.gov).

Expanding biotechnology and improving advanced human health

With expanding research and acceptance of biotechnology solutions, general human health could improve. Advanced therapeutics are increasingly available for not only rare and debilitating diseases, but also chronic conditions such as obesity that could lead to many people living longer and healthier lives. Ensuring equitable access will be a key public priority that will require coordination with the private sector.

IMPLICATIONS:

- Better health and healthcare may lead to a larger than anticipated elderly population, who have different and potentially more complex needs in a disaster context.
- Emergency managers may, themselves, be older or retire later than is currently standard, changing leadership profiles and career advancement opportunities.

SIGNALS:

- The mRNA vaccine to COVID-19 was developed in under a year and FEMA supported the initial vaccine distribution,[47] which included equitable support to vaccination sites via financial assistance, equipment, supplies, and personnel.[48]
- Advanced treatments can improve quality of life and help maintain livelihoods. For example, people with cystic fibrosis now live decades longer than a generation ago,[49] and biotechnology that uses CRISPR can prevent neurodegeneration in Huntington's disease patients.[50]

[47] "COVID-19 vaccine: How was it developed so fast?" 2021. Medical News Today (Medicalnewstoday.com).

[48] "FEMA Supports Vaccine Distribution: COVID-19 Response Update." 2021. FEMA (FEMA.gov).

[49] "The Cystic-Fibrosis Breakthrough That Changed Everything." 2024. The Atlantic (Theatlantic.com).

[50] "An RNA-targeting CRISPR-Cas13d system alleviates disease-related phenotypes in Huntington's disease models." 2023. Nature Neuroscience (Nature.com).https://www.sciencedaily.com/releases/2022/12/221212140550.htm

Improving technology to mitigate emissions and diversify energy systems

Declining costs and increasing scale of technological solutions provide several decarbonization pathways ranging across industries from electric generation to transportation.

IMPLICATIONS:

- The time required to charge electric vehicles and battery range may affect planning for evacuations; unpredictable traffic patterns and high demand for charging stations may compound challenges.
- Natural disasters will affect distributed energy sources differently than in the past.
- Restoring fixed generation assets, backup power, and mobile fuels might mean different things in different places (e.g., clean energy heavy region vs. legacy systems).
- Emergency generation technologies may not just be diesel engines and therefore require different logistics (e.g., hydrogen fuel cells).

SIGNALS:

- In April 2023, President Biden set a goal that at least half of new vehicles sold by 2030 would be electric.[51] In September 2020, California's governor set an executive order that all new vehicles sold in California would be zero-emission by 2035.[52]
- In January 2024, FEMA announced that it would begin paying for solar panels to communities rebuilding from disasters, as a part of the Public Assistance grant program to increase resilience and energy independence.[53]
- In March 2024, the Environmental Protection Agency (EPA) announced historically aggressive pollution standards for passenger cars, light-duty trucks, and medium-duty vehicles.[54]

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[51] "FACT SHEET: Biden-Harris Administration Announces New Private and Public Sector Investments for Affordable Electric Vehicles." 2023. The White House (Whitehouse.gov).

[52] "Governor Newsom Announces California Will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California's Fight Against Climate Change." 2020. Office of Governor Gavin Newsom (CA.gov).

[53] "U.S. Will Pay to Add Solar Panels to Hospitals, Schools After Disasters." 2024. The New York Times (NYTimes.com)

[54] "Biden-Harris Administration finalizes strongest-ever pollution standards for cars that position U.S. companies and workers to lead the clean vehicle future, protect public health, address the climate crisis, save drivers money" 2024. The US Environmental Protection Agency (epa.gov)

Increasing integration of technology into daily life

Facial recognition, improving camera technology, and artificial-intelligence-assisted tools may make tracking people commonplace. As data becomes more public, however, people may become more concerned about their privacy and choose device makers and services that shield them from intrusion.

IMPLICATIONS:

- As facial recognition software and license plate monitoring becomes increasingly widespread, it may become easier to locate missing individuals during a disaster. Any data that emergency managers collect may be subject to leaks. If the public is concerned about sharing their data, it may be more difficult to send targeted messages during emergencies such as text alerts related to location or impact the ease with which individuals can access disaster assistance funding.

SIGNALS:

- New biometric and facial recognition technologies will allow some travelers from La Guardia Airport to fly without providing an ID or boarding pass.[55]
- In spring 2020, many people enabled technology on their phones to track and share their location in relation to others, allowing them to benefit from COVID-19 exposure notifications.[56]

[55] "Facial Recognition: Coming Soon to an Airport Near You." 2024. The New York Times (NYTimes.com).

[56] "We investigated whether digital contact tracing actually worked in the US." 2021. MIT Technology Review (Technologyreview.com)

Mainstreaming of artificial intelligence, machine learning, and access to Big Data

Artificial intelligence (AI) and machine learning algorithms will likely continue increasing across sectors. As a result, real-time communication and data sharing will become increasingly seamless. As AI and Big Data become less expensive, however, fabricated videos or audio messages that appear realistic (deepfakes) and similar detrimental uses will also become more prevalent.

IMPLICATIONS:

- With the help of AI and machine learning, hyper-local weather predictions may improve.
- A smaller workforce may be able to accomplish more by relying on AI tools that speed routine tasks or flag risks.
- Immediately before or after an emergency, misinformation will likely become increasingly problematic as real public safety information is increasingly indiscernible from sophisticated deepfakes.
- Artificial intelligence-assisted attacks will become more sophisticated and difficult to counter.
- The increasing sophistication of AI technologies is anticipated to intensify the complexities surrounding disaster fraud and counterfeiting, thereby opening up new avenues for perpetrators to manipulate and exploit government assistance through fraudulent applications.

SIGNALS:

- In January 2024, a deepfake audio message that appeared to be from President Biden was sent to voters in New Hampshire to discourage them from showing up to the Democratic primary.[57]
- While traditional meteorologists are not yet relying on them, artificial-intelligence-assisted weather prediction services are now "equaling or exceeding the importance of conventional models," according to the Washington Post.[58]
- Researchers at Texas A&M University using AI-assisted technologies can process satellite images within a day after a natural disaster to understand the extent of building damage in an area.[59]

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[57] "The Biden Deepfake Robocall Is Only the Beginning." 2024. WIRED (Wired.com).

[58] "Should we trust AI to predict natural disasters?" 2023. The Washington Post (Washingpost.com).

[59] "Leveraging big data and AI for disaster resilience and recovery." 2023. Texas A&M University Engineering (Tamu.edu).

Increasing use of portable and wearable technologies

Widespread adoption of wearable devices across sectors improves processes such as health tracking and industry efficiency.

IMPLICATIONS:

- Extensive use of wearable devices may ease search-and-rescue operations and contribute to better data on population movements surrounding a disaster. This could improve evacuation guidance and operations.
- First responders may have access to important baseline health information more quickly than today (e.g., someone's smartwatch might be able to flag an arrhythmia, even if the wearer is unconscious).
- Wearable technologies could be used to minimize adverse health outcomes for first responders by notifying the wearer if heart rates or body temperatures rise above a certain threshold.

SIGNALS:

- Apple watches may be able to detect abnormal heart rhythms in older adults.[60]
- Research from Duke and Stanford Universities suggests that information on collected from smartwatches can sometimes predict the results of standard blood tests.[61]

[60] "Can a Smartwatch Save Your Life?" 2021. The New York Times (NYTimes.com).

[61] "Smartwatches Can Predict Your Blood Test Results, Study Finds." 2021. Gizmodo (Gizmodo.com).

Greater sensor connectivity and a more prevalent Internet of Things

More sensors of all types (e.g., weather, air quality, earthquake, fire, chemical contaminants) will be connected to the internet and provide real-time data.[62]

IMPLICATIONS:

- Constant real-time data may provide more warning before a disaster than is currently possible.
- After a disaster, there might be more data available about the extent and type of damage to buildings, structures, and the environment.

SIGNALS:

- ShakeAlert sends notifications to anyone in the impact zone of an earthquake on the West Coast seconds before they feel it. These alerts are triggered by data from seismometers and can provide important warning for preparation.[63]
- The U.S. Environmental Protection Agency and U.S. Forest Service, in conjunction with over a hundred SLTTs, produce AirNow Fire and Smoke Maps based on thousands of crowdsourced data sensors to show exposure currently and potential conditions in the future from wildfires.[64]

62 "What is the Internet of Things (IoT)" (IBM.com).

63 "How Do Earthquake Early Warning Systems Work?" 2024. Caltech Science Exchange (Caltech.edu).

64 "Using AirNow During Wildfires." 2024. U.S. EPA (EPA.gov).

Increasing capabilities of additive manufacturing

The growing field of 3D printing, or additive manufacturing, is increasing accessibility of custom productions. As society grows increasingly reliant on layer-by-layer construction, adaptation will be required to provide compatible materials. This shift will additionally reduce waste associated with the carve-away methodology of traditional manufacturing.

IMPLICATIONS:

- Tools and structures (e.g., temporary shelters) customized to the specific local environment could be produced quickly post disaster.
- With increasing capacity to print necessary resources onsite, complex supply chains may impact disaster response less than they do currently.
- Construction costs for rebuilding homes or large structures may decrease significantly.

SIGNALS:

- New 3D printers can construct the shell of a building in less than a day.[65]
- New materials, such as tungsten powders, can now be used in 3D printing technologies and help to restore supply chains or critical infrastructure capacity more quickly.[66]

[65] "Can 3-D Printing Help Solve the Housing Crisis?" 2023. The New Yorker (Newyorker.com).

[66] "Achieving high-performance pure tungsten by additive manufacturing: Processing, microstructural evolution and mechanical properties." 2023. International Journal of Refractory Metals and Hard Materials (Sciencedirect.com).

Economic Drivers of Change

Size and skills of the workforce increasingly unable to meet demand

While Gross Domestic Product and total employment are projected to increase steadily in the coming decade, the labor force participation rate is expected to fall, growing the labor gap across sectors. Simultaneously, advances in technology will shift workplace portfolios, requiring more technological literacy from employees. Lower skill jobs may additionally need to be automated to keep up with increased strain on the workforce.

IMPLICATIONS:

- Because of increasing costs to attend colleges and universities, there may be fewer people with degrees and the technical skills needed for some emergency management jobs.
- There may be a need for more rapid recruitment and training of new individuals, mechanisms to allow skilled and experienced individuals to leave and rejoin for shorter periods, and compensation packages that incentivize career tracks for essential job roles that have ongoing shortage issues.

SIGNALS:

- In March 2022, the U.S. Department of Labor reported job turnover at its highest in history, which is due to a variety of reasons including worker stress; worker burnout; and potential employees seeking better compensation, benefits, and flexibility.[67]
- One-third of the workers laid off at the beginning of the COVID-19 pandemic will need to be reskilled, since their jobs are not expected to return. The application of new technology to workplaces, such as artificial intelligence, contributes to this reskilling need. This is an amplification of an existing trend, where in 2017, the McKinsey Global Institute estimated 375 million workers globally might need to invest in their careers by 2030. In 2023, the World Economic Forum published a report based on survey results of more than 800 companies, they found that employers expect to create 69 million new jobs by 2027 and eliminate 83 million positions.[68]

[67] "Job Openings and Labor Turnover – March 2022." 2022. Bureau of Labor Statistics (BLS.gov).

[68] "14 Million Jobs Worldwide will Vanish in the Next 5 Years, New Economic Report Finds" 2023. (CNN.com)

Increasing pressure on the food economy

While crop yields may increase in some parts of the world, shifting precipitation patterns, increasing temperatures, and more extreme weather events will disrupt food production and delivery.

IMPLICATIONS:

- Emergency manager portfolios may grow to include overseeing food security for communities.
- Emergency managers may need to increase collaboration with other federal agencies, cross-jurisdictional partners, non-profits, faith-based organizations, and other community partners as climate change disrupts food production and limits food that is locally available and affordable.
- Communities may grow increasingly reliant on long-term food storage. Warehouses may need to hold more inventory, or have inventories replaced at higher cost.

SIGNALS:

- Climate change is causing rapid changes in ecosystem boundaries, especially in the Arctic and Antarctic. As a result of these pressures, there is an increase in illegal, unreported, unregulated fishing. Further, climate change is expected to deplete fish stock, complicate seafood supply chains, and increase geopolitical tensions.[69]
- More extreme weather, including drought, flooding, and changing precipitation patterns is leading to crop and livestock losses across the world. In the U.S., intense drought in some regions coupled with high rainfall in other regions has led to poor yields of wheat, corn, and other agricultural products.[70]

[69] "New Report Predicts How Climate Change and Illegal Fishing Could Threaten Global Ocean." 2023. The Pew Charitable Trusts (Pewtrusts.org)

[70] "The summer drought's hefty toll on American crops." 2022. The Washington Post (Washingtonpost.com).

Declining insurance availability and rising policy prices

The frequency of disasters costing over $1 billion in damage has steadily increased since 1980, with a reduced average interval between such disasters. Insurance has become increasingly expensive, and some providers may exit the market.

IMPLICATIONS:

- The private insurance and reinsurance market is a critical part of recovery from natural disasters but is often determined on a state-by-state basis. Low probability, catastrophic risks are particularly challenging to price, and after an event providers may choose to limit new policies or exit a geographic market entirely.
- Insurers may respond to increasing risk with increased prices for policies. While these increases will help to ensure the survivability of the insurance market, individuals will be priced out of insurance. People in highest risk locations may see the largest rate changes, but those who have fixed incomes or have a large amount of their net worth tied up in the insured property asset may be most impacted.
- In the absence of affordable policies, the government may be forced to step in as the insurer of last resort across damaged areas and geographies.

SIGNALS:

- Intensifying hazards like wildfires have prompted insurers to reduce coverage (e.g., 235,00 policy renewals for wildfire risk were declined in California in 2019).[71]
- Several property and casualty insurers have left high-risk markets, especially in the face of state restrictions on risk-based pricing of rates.[72]

[71] "The Future of Insurance: As Risks Mount, Insurers Aim to Augment Protection with Prevention." 2021. Bain & Company (Bain.com).

[72] "Home insurers cut natural disasters from policies as climate risks grow." 2023. The Washington Post (Washingtonpost.com).

Increasingly complex supply chains and a rise in just-in-time manufacturing

The increasing prevalence of just-in-time manufacturing means that there is less slack in complex supply chains. When one part of the chain is disrupted, there can quickly be cascading effects.

IMPLICATIONS:

- Extreme weather events may disrupt supply chains by delaying production and transit of important materials or products.
- Emergency managers may not have access to critical materials they need for disaster response.

SIGNALS:

- The Texas freeze in February 2021 caused a historic energy blackout. Three major semiconductor plants and railroads faced forced closure. Semiconductor shortages were exacerbated, and supple chain links across the U.S. were hampered severely.[73]
- The COVID-19 global pandemic led to significant supply-chain disruptions and product shortages that negatively impacted numerous business sectors (e.g., shortage of materials for home building). These shortages additionally led to dramatic and lasting price increases, such as in the motor vehicle sector.[74]

[73] "How Climate Change Is Disrupting the Global Supply Chain." 2022. Yale Environment 360 (Yale.edu).

[74] "Why the Pandemic Has Disrupted Supply Chains." 2021. The White House (Whitehouse.gov).

Declining housing affordability and continued urbanization

Mortgage rates have increased dramatically in recent years, and long-term interest rates could rise due to investors' expectations about short-term rates. Urban areas, especially outside the dense core, are predicted to grow by 80% from 2018 to 2030.

IMPLICATIONS:

- Americans may continue moving to areas more exposed to climate-related disasters, expanding into the Wildland Urban Interface and the outskirts of coastal cities.
- Due to high urban population density, disasters in urban areas may have a greater impact and hospital capacity may be reached more quickly.

SIGNALS:

- Areas with homes most at-risk to natural disasters are growing in population, and those areas with the least risk are losing population.[75]
- Duluth, Minnesota, which is relatively insulated from negative effects of climate change and has the infrastructure to accommodate more than 100,000 more residents, has seen its population stagnate in recent years.[76]

[75] "Americans Fleeing Expensive Cities, Moving into Wildfires and Droughts." 2023. Business Insider (Businessinsider.com).

[76] "Want to Escape Global Warming? These Cities Promise Cool Relief." 2019. The New York Times (NYTimes.com).

Political Drivers of Change

Declining international norms and increasing multipolarity

Major powers have geographic affinities, and these blocs compete for power and influence. However, if these international institutions continue to wane, there may be a rise in low-intensity conflict and/or non-state actors. Geopolitical power will shift as countries buy less oil and more minerals for developing clean energy technologies. In addition, corporations and megacities have an increasingly large role in international diplomacy.

IMPLICATIONS:

- There is a move towards economic onshoring and "friend"-shoring in order to mitigate vulnerabilities.[77] The U.S. government has made extensive investments in industrial policy to reshape traditional manufacturing geographies, such as through the National Science Foundation's Regional Innovation Engines program.[78]
- Multi-lateral or bilateral agreements could impact what type of relief aid is available, where it comes from, or what strings are attached.
- While mechanisms for cyber disruption are already available, there is the increased threat that adversaries could use kinetic attacks to disable critical infrastructure that would eliminate essential services to the public, such as access to clean water, power, or natural gas.

SIGNALS:

- Several philanthropic organizations and groups of cities across the world have collaborated on resilience building policy, such as through the Resilient Cities Network.[79]
- The U.S. government has detected state-sponsored cyber actors attempting to preposition code on information technology networks that support civilian critical infrastructure to influence potential policies or actions.[80]
- Increasingly complex supply chains and a rise in just-in-time manufacturing

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77 "What is "friendshoring"?" 2023. The Economist (Economist.com).

78 "Regional Innovation Engines." 2024. National Science Foundation (NSF.gov).

79 "Connecting a city-led network." 2024. Resilient Cities Network (Resilientcitiesnetwork.com).

80 "PRC State-Sponsored Actors Compromise and Maintain Persistent Access to U.S. Critical Infrastructure." 2024. CISA (CISA.gov).

Increasing populism, political polarization, and activism

Increasing dissatisfaction with democracy and widening trust gaps may make people more skeptical of institutions. Public activism targeting both private and public institutions will be more widespread, including mass protests, civil disobedience, and rhetoric over social media.

IMPLICATIONS:

- Reaching consensus through effective leadership in decision-making bodies is increasingly difficult. This could result in reduced legislation, funding, and governance, which would compromise the ability of SLTT governments to meet the emergent needs of the individuals and communities they serve.
- Civil unrest presents a threat within communities, and first responders will have to balance the protection of citizens with their first-amendment rights.

SIGNALS:

- 6% of adults in the U.S. (~20 million people) say that they had attended a protest or rally focused on racial equity between late May and June 2020.[81]
- Most respondents to a 2019 survey from the Pew Research Center, all of whom lived in democratic countries, indicated that they were dissatisfied with "the way democracy was working."[82]

[81] "Recent protesters attendees are more racially and ethnically diverse, younger than Americans overall." 2020. Pew Research Center (Pewresearch.org).

[82] "The Future of Public Activism: Populations Poised to Increase Pressure Worldwide." 2021. Office of the Director of National Intelligence (Dni.gov).

Shifting migration patterns due to refugees fleeing climatic change, conflict, and instability

Growing transnational tension, global instability, and climate-change related disaster will likely continue to increase immigration to the U.S., including individuals seeking asylum. A growing immigrant population may offer a counterweight to the labor gap, providing much-needed workforce support. However, public services may be challenged to expand and adapt to keep pace with rapidly growing and diversifying need.

IMPLICATIONS:

- An increase in immigration may place greater responsibility on local and state leadership, including emergency managers, to plan, coordinate, and protect refugees settling in their communities.
- A lack of community ties may result in increased vulnerability during disaster for recent immigrants, as limited networks provide limited support.
- More immigrants to the U.S. will be moving to escape traumatic circumstances and seek asylum. The socioemotional impacts of their history and immigrant experience may compound trauma tied to disaster experiences following their relocation.
- Increasing language diversity tied to immigration will challenge emergency managers to rapidly adapt notification technology to meet accessibility needs.

SIGNALS:

- In November 2023, more than two million people who sought asylum in the U.S. had not yet received an answer about their application's determination.[83]
- Between November 2022 and November 2023, over 800 thousand people applied for asylum in the U.S.[84]

[83] "Asylum in America, by the Numbers." 2023. The New York Times (NYTimes.com).

[84] Ibid.

Declining fiscal stability

Federal debt is projected to rise from 81% of Gross Domestic Product (GDP) in 2020 to 98% of GDP in 2030. This could necessitate cutting expenditures, raising taxes, or both. However, tax-based fiscal corrections tend to be associated with greater and longer lasting recessions.[85] Community members may experience impacts to their credit ratings that are driven by climate-related consequences.

IMPLICATIONS:

- Emergency managers may experience budgetary pressures that challenge their capacity to operate and sustain emergency preparedness, response, and recovery.
- Infrastructure investments could be displaced by entitlements decreasing resilience.

SIGNALS:

- Sea level rise threatens $619 billion of property that generates $2.4 billion of annual tax revenue. Five million Florida residents "live in towns where 10% of local revenue comes from properties at risk of chronic and permanent flooding."[86]
- Failing infrastructure and lack of adequate repair puts additional pressure on budgets and limits subsequent external investments. Civil engineers have provided safety warnings related to structurally deficient bridges and antiquated water infrastructure. The U.S. is lagging in infrastructure quality and spending compared to other advanced nations.[87]

[85] The Budget and Economic Outlook: 2020 to 2030 | Congressional Budget Office (cbo.gov)

[86] "Climate change is a fiscal disaster for local governments – our study shows how it's testing communities in Florida." 2023. PreventionWeb (Preventionweb.net).

[87] "The State of U.S. Infrastructure." 2023. Council on Foreign Relations (CFR.org).