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Multi-Hazard Early Warning Systems and Building Community Resilience

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Presentation Overview

- The Risk Landscape
- Multi-Hazard Early Warning Systems (MHEWS) Overview
- Community Resilience Overview
- Improving Resilience of Critical Infrastructure and Communities
- Concluding Thoughts

The Risk Landscape

Source: **World Economic Forum Global Risks Report 2020**, *Perceptions of global risks over the next 10 years according to multistakeholders*

- Changes in the frequency, intensity, and unpredictability of extreme weather events are being driven by climate change
  - Disaster preparedness and disaster risk understanding are even more critical to protecting communities

Image Source: **National Oceanic and Atmospheric Administration (NOAA)**, *Hurricane Michael makes landfall*, October 10, 2018 https://www.nesdis.noaa.gov/content/hurricane-michael-makes-landfall

The Risk Landscape

- Hazards include the following processes and phenomena
  - Biological
  - Environmental
  - Geological
  - Hydrometeorological
  - Technological

Due to ever-evolving environmental and climate changes, early warning systems (EWS) are essential to preparing communities and building resilience

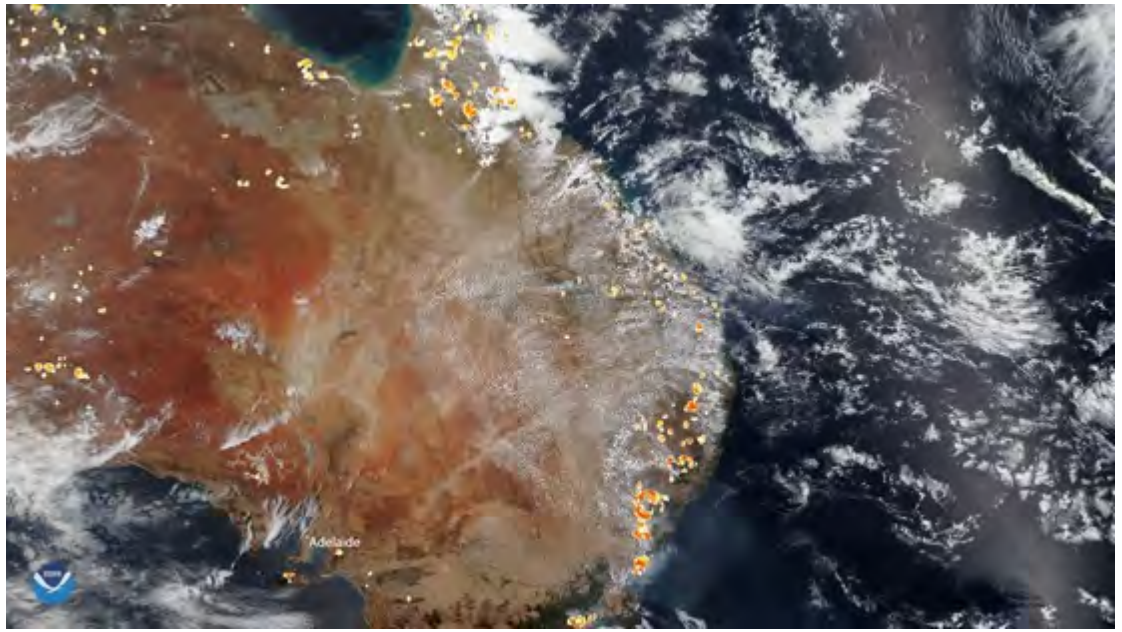

Image Source: **National Oceanic and Atmospheric Administration (NOAA)**, *Fires continue to burn in Australia's Southeastern states*, December 27, 2019
https://www.nesdis.noaa.gov/content/hurricane-michael-makes-landfall

WMO, 2018, Multi-hazard Early Warning Systems: A Checklist, Outcome of the first Multi-hazard Early Warning Conference, 22 to 23 May 2017, Cancun, Mexico, available at https://reliefweb.int/sites/reliefweb.int/files/resources/Multi-hazard_Early_Warning_Systems_A_Checklist.pdf

Multi-Hazard Early Warning Systems (MHEWS)

"The dramatic reduction in the lives lost due to severe weather events in the last thirty years has been largely attributed to the significant increase in accuracy of weather forecasting and warnings and improved coordination with disaster management authorities"

- World Meteorological Organization (WMO), Secretary General Petteri Taalas

- MHEWS address several hazards and/or impacts of similar or different types in contexts where hazardous events may occur alone, simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects
- MHEWS with the ability to warn of one or more hazards increase the efficiency and consistency of warnings through coordinated and compatible mechanisms and capacities, involving multiple disciplines for updated and accurate hazards identification and monitoring for multiple hazards
  - Defined by Member States of the United Nations, 2017

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Multi-Hazard Early Warning Systems (MHEWS)

Early Warning is defined as "the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response"

- United Nations Office for Disaster Risk Reduction (UNDRR) terminology

"Ten seconds is time to turn the gas off if you're cooking and that could make all the difference between your house burning down or not"

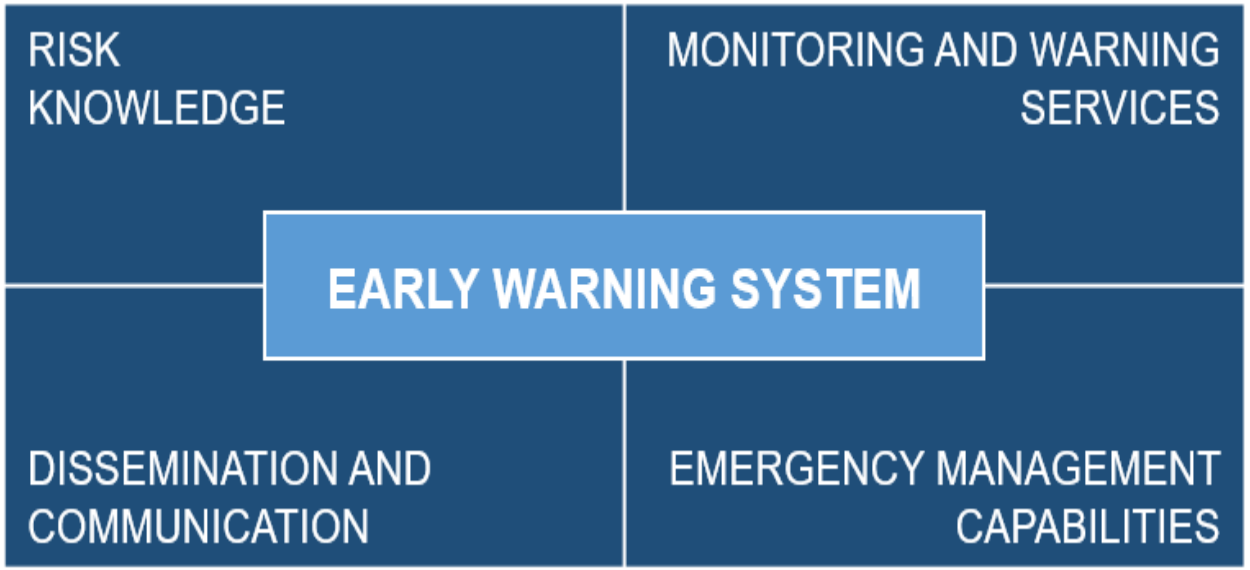
- Seismologist George Mussonn

- Evidence from literature concludes **for every minute delay in primary response for certain life-threatening medical emergencies, there is a measurable effect on mortality**
- Technology advancements with sensors, analysis of historic events, improved communications, and increased data availability all factor into increasing warning system effectiveness
- Data from previous disasters can be used create and/or improve future warning systems
- MHEWS help communities become better prepared for hazards and allow for stronger resilience measures to be put in place

Four Elements of Effective Early Warning Systems

"Early Warning Systems (EWS) are well recognized as a critical life-saving tool for floods, droughts, storms, bushfires."

- World Meteorological Organization



WMO. 2019. Disaster Risk Reduction (DRR) Programme; Multi-Hazards Early Warning Systems (MHEWS). Available at https://www.wmo.int/pages/prog/drr/projects/Thematic/MHEWS/MHEWS_en.html
Graphic: *Adapted from ISDR, 2006; ISDR, 2006*

Technology and Early Warning Systems

- Technology is the driver of improved timeliness and effectiveness of EWS
  - Communities are embracing technology through:
    - New communications media (e.g., text messages, social media)
    - Advanced decision support systems
    - Sensor networks to collect data on movement, communication, and response activities
    - Data collection and analysis following disasters
    - Disaster simulation technology to stress test current EWS and improve on the weaknesses of current technology

Challenges for MHEWS

Several challenges remain to make these systems fully efficient and available to all:

- **Development of risk identification and knowledge**
  - Risk precursors and parameters still need to be defined for some hazard types
- **Capability to monitor phenomenon of different natures while providing clear and useful warnings**
  - This involves the ability and tools to collect and manage a large quantity of data that must be analyzed in real-time
- **Ensure effective distribution and communication systems for all communities**
  - This challenge is not just about the availability of adapted communication mechanisms (e.g., radio, television, wireless communications, and Internet), but also the difficulty to share information that could identify vulnerabilities
- **Complexity and cost to deploy EWS for all communities and all hazards**
  - It can be difficult for poorer communities, that are generally the most vulnerable, to finance equipment needed to support EWS

Resilience Defined

"the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management"

- United Nations Office for Disaster Risk Reduction (UNDRR), 2017

"the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions.
Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents"

- Presidential Policy Directive (PPD) 21, 2013

Community Resilience

- Communities are generally comprised of:
  - Individuals and families, including those with access and functional needs
  - Businesses
  - Faith-based and community organizations
  - Nonprofit groups
  - Schools and academia
  - Media outlets
  - All levels of government, including state, local, tribal territorial, and federal partners
- **It is important to develop resilience measures to support adaptive and flexible risk management processes and to promote sustainable development for communities**

Nine Core Elements of Community Resilience

1. Local knowledge
2. Community networks and relationships
3. Communication
4. Health
5. Governance and leadership
6. Resources
7. Economic investment
8. Preparedness
9. Mental outlook

Patel, S.S., M.B. Rogers, R. Amlôt, and G.J. Rubin. 2017. *What do we mean by 'community resilience'? A systematic literature review of how it is defined in the literature. PLOS, Currents Disasters*. Available at: http://currents.plos.org/disasters/article/what-do-we-mean-by-community-resilience-a-systematic-literature-review-of-how-it-is-defined-in-the-literature/?utm_content=buffer66cd1&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

U.S. Federal Emergency Management Agency (FEMA). 2018. Whole Community. Official website of the Department of Homeland Security. Available at https://www.fema.gov/whole-community

Four Pillars of Resilience

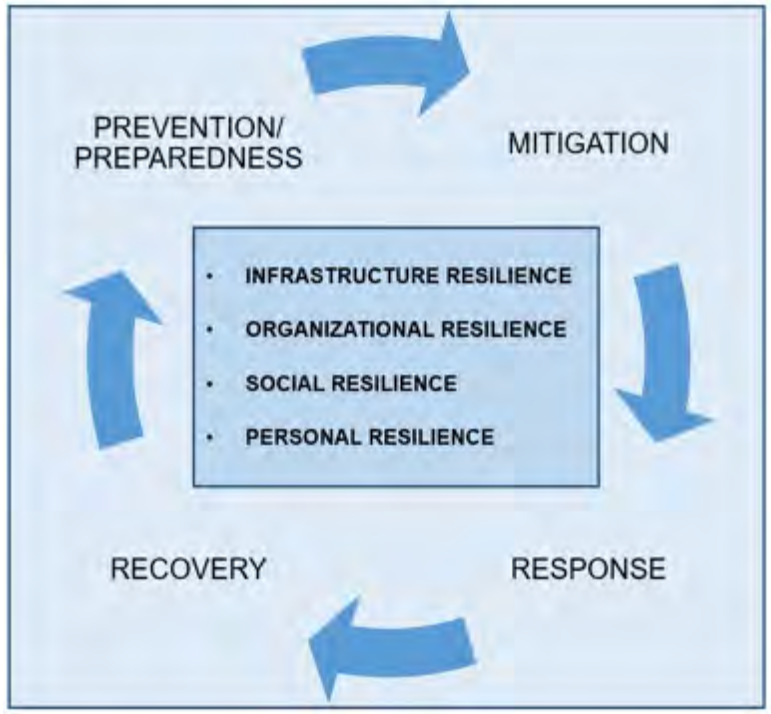
Community resilience is comprised of four pillars: infrastructure, organizational, social, and personal; all of which need consideration when developing, implementing, or improving an EWS

- **Infrastructure Resilience**
  - considers the continued operations of utilities, businesses, industries, and critical infrastructure systems, as well as their interdependencies; which can affect community supply chains
- **Organizational Resilience**
  - considers the ability of governmental and nongovernmental organizations to continue to function in the event of a disturbance
- **Social Resilience**
  - considers the ability of individuals to organize in structured groups, combining diverse interests, skills, and resources, and to coordinate their efforts
- **Personal Resilience**
  - considers the ability of general public to respond to challenge, setback, and even crisis

Examples of Community Resilience Frameworks

U.S. National Institute of Standards and Technology (NIST) Community Resilience Planning Guide (NIST, 2018)	Step process to planning for community resilience: 1. Form a collaborative planning team 2. Understand the situation 3. Determine goals and objectives 4. Plan development 5. Plan preparation, review, and approval 6. Implementation and maintenance
Global Facility for Disaster Reduction and Recovery (GFDRR)	Pillars to improve in-country capability to prepare for and recover from natural disasters: 1. Risk Identification 2. Risk Reduction 3. Preparedness 4. Financial Protection 5. Resilient Recovery
International Federation of the Red Cross and Red Crescent Societies (Red Cross, 2016)	Stages on the Road Map to Community Resilience: 1. Engage and Connect 2. Understand community risk and resilience 3. Taking action for resilience 4. Learning for resilience

Core Characteristics Contributing to Community Resilience



- Prevention: activities and measures to avoid existing and new disaster risks
- Preparedness: knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters
- Mitigation: lessening or minimizing of the adverse impacts of a hazardous event
- Response: actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected
- Recovery: restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and 'build back better,' to avoid or reduce future disaster risk

Definitions: United Nations Office for Disaster Risk Reduction (UNDRR), 2017

MHEWS: Improving Resilience of Critical Infrastructure and Communities

- **EWS are not a singular solution to making a community resilient**
  - They are a key component to helping communities respond to impending danger and recover from disasters – ultimately enhancing resilience to all hazards
- **When a disaster strikes, impacts will be felt across entire communities and within all their components**
- **It is difficult, if not impossible, to fully protect a community against all types of hazards**

The primary objective of an EWS is to better anticipate and understand hazards and support the preparedness of communities and their assets (e.g., infrastructure, organizations, and population) to reduce detrimental consequences

Examples of Early Warning Systems

- **Tornado Sirens in the United States**
  - Use of tornado sirens was banned from 1887 to 1938, with rapid expansion after 1948
  - Today warnings are dispersed via outdoor warning sirens, local television and radio stations, cable televisions systems, cell phone apps, and NOAA weather radio
- **Heat Health Warnings in France**
  - Following the deadly 2003 heatwave, France developed a Heat Health Warning System to anticipate heat waves
  - June 2019 was the hottest month on record; heat health early warnings limited the death toll
- **Tsunami Warnings in Japan**
  - Tsunami warnings began in the 1940s
  - Following the devastating 2004 Indian Ocean tsunami, a global system was developed and implemented along tsunami-threatened coastlines

Examples of Early Warning Systems

- **Malaria EWS in Africa**
  - The Malaria Early Warning System (MEWS) uses vulnerability indicators, transmission risk indicators, and early detection indicators to predict the timing and severity of a malaria epidemic
  - Successfully reduced the burden of malaria to low levels and now in the process of eradication
- **ShakeAlertLA in Los Angeles, California**
  - Recently introduced to provide earthquake early warnings to app users via push notifications
  - Feedback from users led to lowering the threshold for user notification as they preferred more alerts over less
- **Cyclone EWS in Mozambique**
  - Multiple cyclones led to needed EWS efficiency
  - Significant improvements were needed for flood warnings; cyclone warnings were sufficient
  - Communications needed to be simplified; communities needed ongoing education and awareness

Examples of Early Warning Systems

- **Flooding Warning Systems in Semarang, Indonesia**
  - 100 Resilient Cities member
  - Developed EWS for flooding through a multi-stakeholder, collaborative approach
  - Goal to reduce deaths and injuries through increasing knowledge and action planning
- **Flooding Warning System in Bosnia and Herzegovina and Serbia**
  - Implemented cross-border monitoring and forecasting with an enhanced EWS
  - Cost savings as meteorological models are shared in this consolidated effort
  - Improves local weather forecasts and enhances EWS effectiveness

Advancing Warning Systems through Technology

- **Social Media**
  - Social media networks can be used to share information before, during, and after disasters as a means for sending warnings, conducting situational awareness, as well as catalyzing action and sustaining feedback loops
- **Apps**
  - The use of mobile phone applications has been on the rise, allowing communities to quickly and easily notify individuals of extreme climate events
    - One example is the “DisasterAlert” app, which alerts users in the U.S. of earthquakes, tornadoes, hurricanes, tsunamis, ice, flood, freezing, fire, wind, and snow
- **Sensors**
  - The use of sensors to detect or predict potential climate events has been and continues to be tested and implemented to enhance EWS

Concluding Thoughts

- **EWS have changed the way communities prepare for, respond to, and recover from disasters**
  - Timeliness and accuracy are two primary components to an effective EWS within communities, along with four key elements:
    - risk knowledge
    - monitoring and warning services
    - dissemination and communication
    - emergency management capabilities
- **Communities can continue to enhance their MHEWS by applying best practices and lessons learned, as well as implementing new technologies as they become available**
- **EWS are not a singular solution to making a community resilient, but they are a key component to helping communities respond to impending danger and recover from disasters**

Concluding Thoughts

The equation below proposes a holistic resilience measurement approach

$$Res = f(aIR, bCR, cOR, dSR, ePR)|_r$$

Where:

Res = resilience;

f = function of;

a,b,c,d,e = scaling constants that vary from 0 to 1, depending on the risk being considered;

r = risk, considering interdependencies that potentially affect all risk components (threat, vulnerability, and consequence); and

$|_r$ = evaluated at varying levels of risk.

- ***Resilience is a function of infrastructure resilience (IR), community resilience (CR), organizational resilience (OR), social resilience (SR), and personal resilience (PR)***
- ***Weighting varies based on factors that change***
- ***Risk is a function of threat, vulnerability, and consequence that needs to be considered as part of measuring resilience***
- ***Resilience must be measured in context of risk consideration***
- ***Interdependencies must be considered in this resilience framework (via risk)***

Fisher, R., Norman, M., and Peerenboom, J. (2018). *Resilience History and Focus in the United States*. United States.

Thank you!

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