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Research Note

Early Warning Detection Systems

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Abstract – Advances in technology have greatly improved the ability to detect natural disasters through early warning detection systems. System improvements associated with fire, flood and earthquakes are discussed and recommendations for ways risk managers can improve their risk preparedness plans are provided. The potential impact of social media as a tool for communicating information during a crisis is also discussed.

Introduction

As implied by the name, early warning detection systems are tools used by governments and private organizations to communicate a potential or impending problem before the event occurs.[1] Over the last two decades technological advances have allowed researchers to dramatically improve the detection of natural disasters and provide a means to warn the public before the disaster strikes. Although the technology to predict many forms of disasters may not yet exist, the development of early warning systems that detect fires, earthquakes, floods and other natural disasters are becoming more prominent and are appropriately credited with saving thousands of lives. This research note will analyze early warning systems associated with wildfire, floods and earthquakes and discuss ways organizations and governments can utilize these systems to improve their emergency preparedness plans.

Wildfire

Each year in the United States, more than 100,000 wildfires completely clear four to five million acres of land.[2] Recent years have been even more damaging, with up to nine million acres of land being burned.[3] Due to several environmental factors, detecting forest fires and the paths they may take can be a difficult undertaking. But researchers with Edith Cowan University's Centre for Communications

Engineering Research are hoping to change that in the near future by "deploy(ing) a large test of wireless sensors that detect forest fires and broadcast the results to the world."[4]

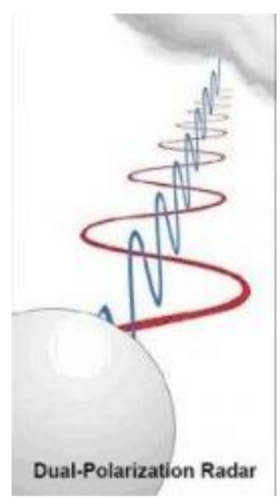
The system works by utilizing proprietary mesh networking software, connected to palm-sized sensors scattered throughout the forest and connected to a wireless network.[5] The sensors can "detect carbon monoxide and carbon dioxide levels found in forest fires… (and) broadcast findings to researchers or the general public via Twitter or on the Internet."[6] Current remote sensors have a line of site capability of 500 feet, and have the ability to "detect up to 16 different types of environmental factors, including gas levels, atmospheric pressure, humidity and temperature."[7] Small trials of the system have been successfully conducted in highly controlled environments, but researchers are looking to deploy larger tests in the future to get a better sense of the system's capabilities and limitations.[8]

A wildfire may seem unlikely to those in urban environments, but obviously fire is a threat risk managers should consider and be prepared for. Fire drills and evacuation should be held at least once a year.[9] In addition, professionals recommend10 employees know how to:

- Activate the fire alarm if they discover a fire
- Contact the fire department
- Use fire-fighting equipment appropriate for the circumstances
- How to evacuate the building
- Where to assemble and who to report to

Floods

Floods are characterized by having "more water flowing through the hydrological system than the system can draw off."[11] From a risk management perspective, it is important to make the distinction between a regular river flood, where water slowly raises over the edge; and a flash flood, when a wall of water quickly sweeps over an area.[12] "Almost three-quarters of the approximately 92 deaths from floods each year are due to flash floods."[13] Unlike some natural disasters which are nearly impossible to predict, improving weather forecasting tools are enhancing the ability to predict floods.



The National Weather Service (NWS) recently upgraded Doppler technology to include a tool called dual polarization. As seen in the image to the right,[14] dual polarization allows Doppler to transmit and receive information from the atmosphere both horizontally and vertically, consequently, the ability to predict precipitation types and estimates will become more accurate.[15] All 160 NWS offices should have this new technology installed by the end of 2013.[16]

Receiving extreme weather alerts through television and radio is not a new phenomenon; however, several applications for mobile phones are now conveniently accessible through multiple mobile platforms and enable extreme weather notifications to be easily delivered to mobile devices. In addition, a highly sophisticated prototype for a flood early warning system developed by a global community of researchers:

> "Monitors sensor networks installed in flood defenses (dikes, dams, embankments, etc) detects sensor signal abnormalities, calculates dike failure probability, and simulates possible scenarios of dike breaches and flood propagation."[17]

The relevant information gathered from these sensors is then sent to a decision support system, where managers can analyze the data and make more informed decisions.[18]

From a risk management perspective, identifying the types of flood risk an organization or municipality is exposed to and preparing a flood mitigation plan is critical. Taken from the Environment Agency (EA),[19] a flood plan for a business should consist of:

- A list of important contacts, building services, suppliers and evacuation contacts for staff.
- A description or map showing locations of key property, protective materials and service shut-off points.
- Basic strategies for protecting property, preventing business disruption and assisting recovery.
- Checklists of procedures that can be quickly accessed by staff during a flood.

The EA also correctly points out that if a flood is imminent, the primary concern should be the safety of the staff.[20]

Earthquakes

As discussed in a previous research note, earthquakes are caused "by the sudden breaking and movement of large sections (tectonic plates) of the earth's rocky outermost crust."[21] The extreme strength of two massive moving plates causes the crust to rupture at its weakest point.[22] When an earthquake occurs, waves of energy caused by the sudden breaking of rock travel through the earth and are recorded on seismographs.[23] Although earthquakes produce multiple types of measurable waves, early detection warning systems are largely interested in primary and secondary waves.

A primary wave (also referred to as a P wave, pressure wave or compressional wave), is the fastest kind of seismic wave and has the ability to move through solid rock and fluids, pushing and pulling through the earth in a similar way that sound waves push and pull through the air.[24] "Depending on the magnitude and the composition of the ground layers the P wave generally travels somewhere between 4 to 8 km/second."[25] A secondary wave (also referred to as S wave or shear wave) is "slower than a P wave and can only move through solid rock, not through any liquid medium."[26] S waves travel at approximately sixty percent[27] of the speed of the P wave and are the waves responsible for the majority of the strong shaking felt in a quake, as they "move rock particles up and down or side to side."[28]

Early warning detection systems are able to identify the faster traveling P waves and provide an advance notice of the heavy shaking that will come with the trailing S waves. As soon as the P waves are detected, data is gathered and processed and alerts are sent via television, radio, the Internet and mobile phones. The amount of warning the systems are able to provide depends upon the location relative to the epicenter of the quake. "Communities closest to the epicenter will receive no warning because they fall within what is known as the 'blind zone.'"[29] But communities further from the epicenter may receive "tens of seconds to more than a minute of warning time, but they are also less likely to experience damage from the shaking."[30] A few seconds warning may not sound like a consequential figure, "but for areas about to be rocked by seismic waves, those seconds can give emergency managers and the public just enough time to prepare and perform life-saving tasks, as well as trigger automated systems designed for such a situation."[31]

Despite the high monetary investment associated with early earthquake detection systems, countries around the globe have determined that the additional preparation time granted to their citizens is worth the cost.[32] An advanced system, similar to Japan's, has been planned for the Bay Area in northern California and along the west coast of the United States, but has "languished for more than five years, stuck in a perpetual test phase because of a lack of government funding."[33] A fairly recent grant of $6 million dollars should help the project progress, but officials close to the project say much more funding will be needed.[34]

As discussed earlier, the seconds to minutes of advanced warning provided by these systems, can actually provide enough time to take significant safety measures. Summarized from research[35] conducted by Richard Allen of the University of California, Berkeley, the following suggestions illustrate possible ways governments and organizations could utilize the advanced warning systems:

- Trains could be slowed or stopped and positioned to avoid bridges or tunnels
- Airplanes on final approach could be issued “go around” commands
- Streetlights could be turned red – preventing cars from entering hazardous structures like tunnels or bridges
- Workers in hazardous environments could move to pre-determined safe zones
- Sensitive equipment could be automated to be put in a holding mode, limiting the risk of injury or damage
- Office workers and school children could get under desks before the shaking arrives

Conclusion

As risk managers consider the threat posed by each of these natural disasters, it’s important to understand that the circumstances of each individual organization or community are going to be unique. As technology continues to improve the functionality of various early detection systems, the ways in which these systems can positively impact and improve safety will also increase. Organizations should take the time to research existing warning systems in their own communities, many of them are public services and provided at no cost. Many universities and private organizations also provide different types of warnings systems which should also be considered for inclusion in disaster preparedness planning.

In addition, both public and private organizations should not be afraid to utilize social networking tools as part of their disaster preparedness plans. Following a 2011 fire that swept through a small Canadian city, officials commented that "the fire was moving so fast it was impossible to issue a bulletin through their public warning system."[36] In the aftermath of the fire, they learned that information was not being received through traditional channels like television, radio or mobile phone, but that people were constantly checking Facebook.[37] Social networking should not be the only means of crisis communication, but it should be considered for inclusion as one tool in a larger toolkit.

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