



TRANSLATING WARNINGS INTO ACTIONS

HOW WE CAN IMPROVE EARLY WARNING SYSTEMS TO PROTECT COMMUNITIES

April 2023

SHORT REPORT SUMMARY

Early warnings for hazards are essential for living safely and minimising economic losses. For many hazards, it is possible to give advance notice and accurate information to help communities prepare and respond. However, issuance of the warning itself is not enough for a warning system to be effective, as the effectiveness of warnings is determined by the quality of the overall response.

Successful early warning systems rest on long-term foundations, including strong relationships, good governance, a multi-hazard approach, and explicit consideration of diversity and vulnerability in the community. The systems built on those foundations should incorporate a strong understanding of community risk, the best possible science and observations for giving advance and accurate information, well developed and tested preparedness and response capabilities, and empowering, inclusive communication of potential hazard impacts to communities and individuals. Early warning systems should integrate 'top-down' and 'bottom-up' approaches to achieve a community-focused, co-production approach at local, national, and international levels.

The history of disasters is replete in examples where failure in any of these areas has failed the community. There have also been many inspiring models of good practice, where thousands of lives have been saved through the actions of communities and those involved in early warning systems. But even where warnings have been largely effective as, for example, at the enormous eruption of Mt Pinatubo, Philippines, in 1991, there is scope to keep improving outcomes.

Whatever our role in early warning systems, there are ways in which all stakeholders can work together to ensure early warning systems better protect people and their livelihoods. These include building long-term foundations and community trust, better risk knowledge, observations, data sharing, and forecasting systems, preparedness and response measures, and communications approaches such as impact-based warnings and the use of the Common Alerting Protocol to help give warnings wider and more consistent reach. Whatever is done will be more successful if we prioritise long-term, respectful relationships within the complex warning system.

This short report was commissioned by the International Federation of Red Cross and Red Crescent Societies to assist in promoting global actions for improved early warning response. The report was principally authored by Dr Andrew Tupper, with input from Dr Carina Fearnley and Professor Ilan Kelman, on behalf of the University College London Warning Research Centre, United Kingdom.

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Introduction: Life or Death

.... a mother gathers her children to leave ahead of an oncoming typhoon....

.... firefighters discuss where to attack a fire front without risking their lives....

.... a man leaves the shelter to feed his cattle, in the evacuation zone further up the volcano....

.... volunteers scurry from house to house in the dark, urging everybody to flee an imminent tsunami and giving assistance as required, as sirens sound a warning....

.... a ship navigates past an enormous, dangerous storm at sea....

.... a head of government orders a general mobilisation and calls for international assistance as a flood disaster worsens...

.... an international relief effort swings into place, coordinating multiple agencies and countries in a desperate race to save lives and property whilst the dangerous conditions still exist....

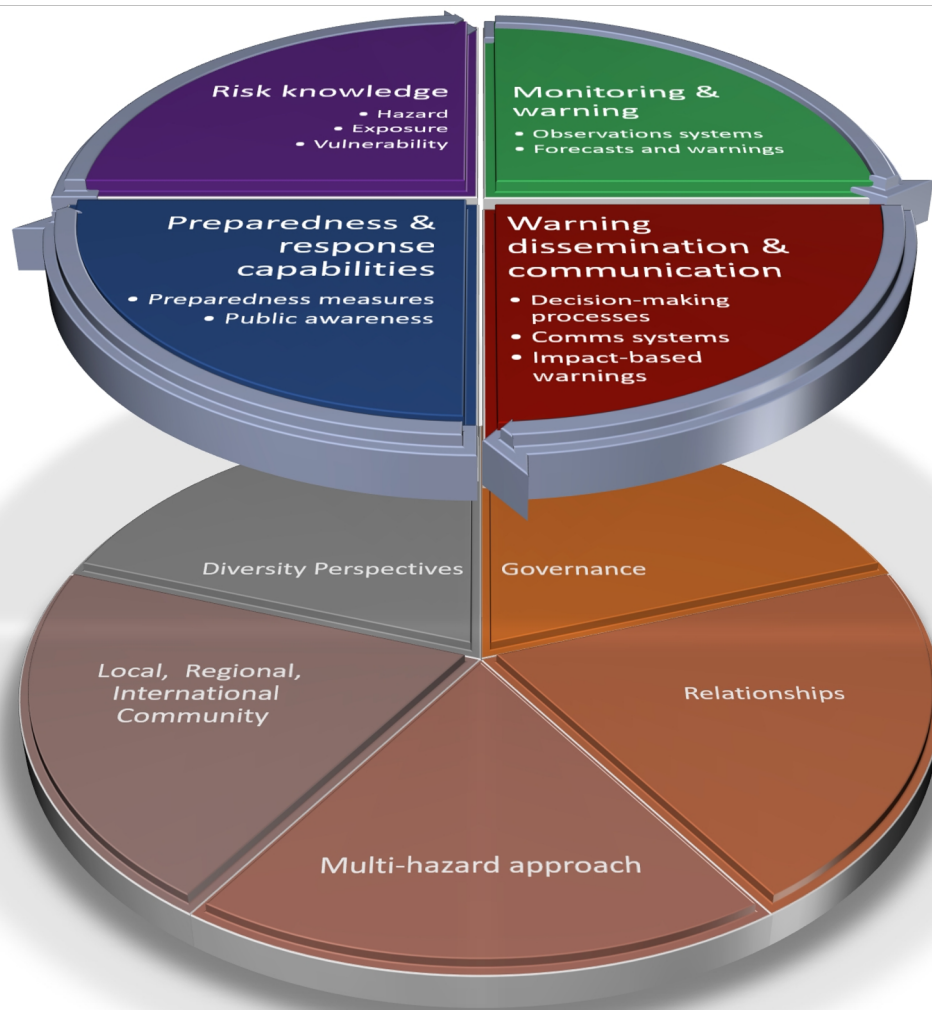
What do these scenarios have in common? In each case, the decision makers are helped by the best possible information they can get from early warning systems, combined with their trust in that information and ability to determine their own courses of action. And in each case, the design and implementation of the warning systems can make the difference between life and death for those exposed to the hazards.

Early Warning System concepts

An early warning system is “an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events.” At United Nations level, the global improvement of EWS is a commitment within the Paris Agreementⁱ and is one of the key targets of the Sendai Frameworkⁱⁱ, but implementation is significantly lagging across the worldⁱⁱⁱ. In March 2022, the UN Secretary-General announced that the United Nations will spearhead new action to ensure every person on Earth is protected by early warning systems within five years.^{iv} This is a very ambitious goal as simple coverage is not enough: early warning systems must be co-owned by communities to be effective.

End-to-end early warning systems include four basic elements: risk knowledge, monitoring and forecasting, warning dissemination and communication, and preparedness and response capabilities.^v However, these elements work within the context of cross-cutting foundational elements, shown here with five critical enablers: governance and institutional arrangements; the strength of relationships, an integrated multi-hazard approach, local to global community engagement, and consideration of diversity perspectives. Early warning systems are part of a social process – a set of long-term actions to reduce disaster risks in advance of hazards.^{vi}

No role within this framework is trivial – whether a community organiser helping communities at ground level, a local official sending observations to be shared around the world, or a scientist using those observations to implement weather prediction models that see further into the future, the system works best when everybody is playing a part. A well-implemented early warning system works inclusively^{vii} to create authentic co-production of warnings – information that is collected, owned, and used by the community as part of our cooperative activities for the global good^{viii}. The more successful an early warning system is at collaboratively integrating these facets, the more successful it will be at saving lives and enhancing economic prosperity.



Conceptual summary of early warning system components (top layer) and foundational cross-cutting elements (bottom layer). Adapted from Trogrlić et al (2022), Fearnley et al (2021), WMO (2018), and others.

Making the critical difference: examples of successes and failures in translating early warnings to action

The history of early warning system development is strewn with 'big events' that have helped drive progress through examination of their successes and failures. Here are a few significant examples.

Hard lessons from the Titanic: warnings must translate into action

Early warnings do not always translate into early actions. Perhaps the most famous disaster-related example of this in recent history was the sinking of the *S.S. Titanic* in 1912, for reasons described by the British Inquiry as 'collision with an iceberg, brought about by the excessive speed at which the ship was being navigated'^{ix}. The captain and crew of the ship were well aware of the presence of icebergs in the area, having been informed through multiple warnings from other ships in the area. 1503 lives were lost. The disaster resulted in the development of the International Convention for the Safety of Life at Sea (known as SOLAS), which sets out minimum safety standards in the construction, equipment and operation of shipping, including the *behaviour* of mariners around known navigation and weather hazards.

This interplay between early warnings and effective response actions is critical to an understanding of early warning actions. An early warning – informed by the best possible observations, analysis, and scientific forecasting – is useless if it does not result in preventative actions. A passenger ship is a more extreme example because large numbers of lives are placed in the hands of a small number of crew, with accountability resting on a defined individual, and very limited opportunity for passengers to influence their fate. However, in conceptual terms, a similar situation applies in many different hazard contexts. Typically, those who suffer most from natural hazards are the poor or marginalised^x, who have limited self-agency, just as steerage passengers on the *Titanic* had a lower chance of survival. For example, land subject to flooding is generally cheaper than ‘safe’ land, and so those who have less resources will end up on the floodplain. In this situation, it usually falls to governments, supported by others such as civil society organisations, to take on the role of ‘captain’, by making decisions and taking actions on behalf of the people. A solely ‘top-down’ approach is less than ideal though, as it robs the marginalised of their decision-making agency.

The best early warning systems bring ‘bottom-up’ and ‘top-down’ approaches together - where a mixture of local, national, and international frameworks can be integrated in a community-focused, co-produced system, better outcomes are achieved^{xi}.

The 1970 Bhola cyclone: the importance of consistency and the influence of governance at varying levels

The devastating Bhola cyclone in November 1970 in what is now Bangladesh (then East Pakistan) is one of the low points in the history of disaster management, with the loss of over 300,000 lives. The cyclone occurred following a period of neglect of the early warning system, which included poor flood control measures and a damaged radar station on the coastline^{xii}. At that time, satellite meteorology was in its infancy, and weather radar was an even more critical tool for cyclone detection and tracking than it is today. However, there were more than technological issues at play. Media reported that using satellite sources, US authorities had notified the Pakistan government of the cyclone several days before landfall, but that these international warnings were not translated into local actions:

“People were not, as on previous occasions asked to take shelter in community centres, pucca [concrete] schools or other places comparatively safe. And that the Radio changed its traditional system and did not give the danger signal number that usually accompanies storm warnings and indicates how serious the storm is going to be. The usual procedure of announcing a warning by beat of drum in the cyclone zone was also not reportedly followed.”^{xiii}

A mismanaged disaster relief effort soon followed, and as the scale of the disaster became apparent, it became associated with political demands for self-autonomy, contributing to the division of Pakistan and creation of Bangladesh in 1971^{xiv}.

Bhola showed failures at multiple critical junctures – failure to observe, to trust external information, to pass on warnings to the affected population, and to respond appropriately. However, the catastrophe stimulated enormous interest in disaster response, resulting eventually in producing a ‘social contract to protect the population against disasters and subsistence crises on which the country’s acclaimed resilience to the effects of climate change rests’^{xv}. Enormous progress has occurred since, driven from many levels including from government, scientific, and community-embedded civil society organisations¹. In that sense, and combined with its existential impact on the political situation, the disaster helped create clear standards for what is expected of government, early warning agencies, and responders during and after a crisis.

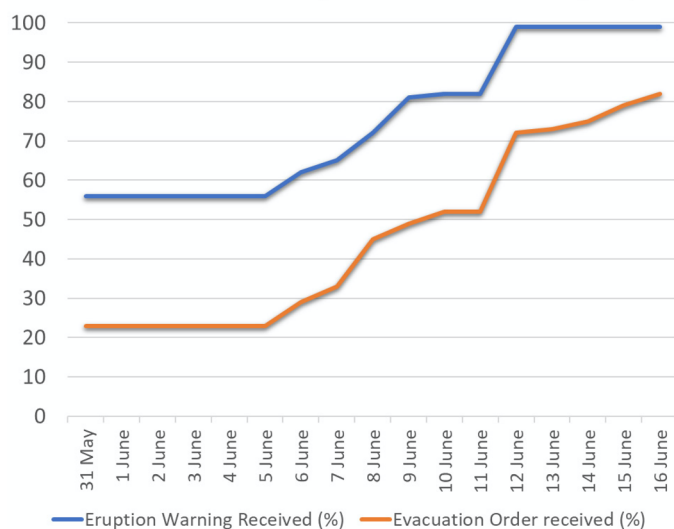
¹ For example, the Bangladesh Red Crescent Society operates the [Cyclone Preparedness Program](#), a major, long-term program for assisting in warning dissemination, community response, and disaster recuperation.

Mt Pinatubo, Philippines, 1991: a triumph of community engagement in the face of potential catastrophe, but still with lessons to learn

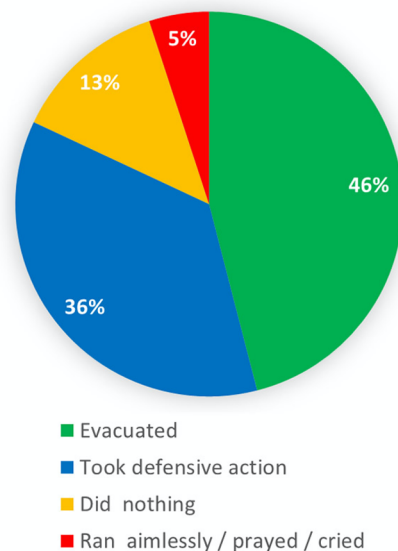
The management of the eruption of Mt Pinatubo and simultaneous impact of Typhoon Yunya (Diding) showed many outstandingly positive elements of how well early warning systems can work.

Response to warnings and evacuation orders

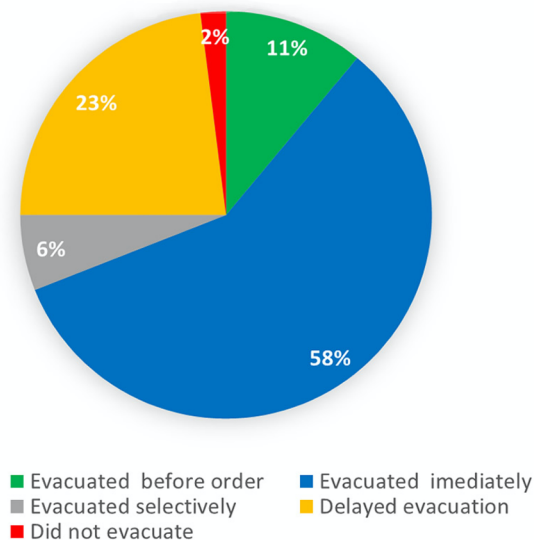
a) Receipt of eruption warnings and evacuation orders within 40 km of Mt Pinatubo prior to 15/16 June 1991 eruptions



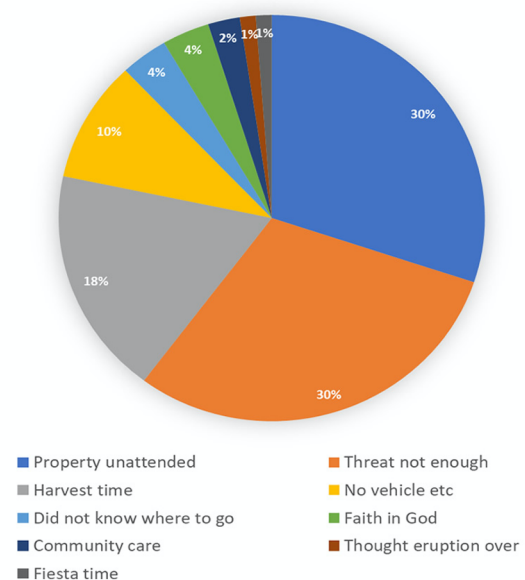
b) Response to pre-eruption warning



c) Response to evacuation order



d) Reasons for non-evacuation



Post-event surveys of residents affected by Mt Pinatubo showed that, despite the overall success of event management, there was still lots of room for improvement. Eruption warnings and evacuation orders were not received by everybody prior to the commencement of major eruptions on 12 June 1991. When eruption warnings were received, not all responses were effective, and similarly for evacuation orders. On exploring more deeply the reasons for non-compliance with evacuation orders, most reasons given (for example, the need to look after livestock and the difficulty of leaving the property) were 'reasonable' and could be addressed with enough effort. Source: Adapted from Tayag et al, 1996.

Between the time of the first small explosions at the previously unmonitored volcano on 2 April 1991 and the climactic eruption on 15 June 1991, a joint Philippine-United States team worked tirelessly and passionately together to avert most of the potential disaster, reaching out to all levels of their respective governments^{xvi}. At least 58,000 people were evacuated prior to the climactic eruption, and although hundreds still died due to roofs collapsing from wet, typhoon-affected ash and from volcanic lahars, many thousands of lives were saved^{xvii}. Considering the highly dangerous situation, with massive eruptions as well as torrential rain from the typhoon, the result was extraordinary. Key factors behind the success included a strong, respectful relationship between the parties, with the United States Geological Survey supporting the Philippine Institute of Volcanology and Seismology in undertaking their role, and strong public education measures including a freshly produced educational video used with the indigenous Aetas^{xviii}. The broader effort was also supported by the typhoon warning system and broader meteorological frameworks (including cooperation between the Philippines and Japan for sharing satellite information).

Despite these successes, the experience showed a gap between warning issuance and receipt, and receipt and response actions on the ground.^{xix} And despite the widespread observations and warnings, at least sixteen damaging encounters between volcanic ash and passenger aircraft occurred, although fortunately without further loss of life^{xx}. These events highlighted that, even when an early warning system appears to be working relatively well, it will be subject to a number of failures – *every event is an opportunity for continuous improvement*.

Hurricane Sandy, USA, 2012: the roles of social media and individuals.

Whether a subsistence farmer or a head of State, the recipient of a warning will not necessarily take action unless they trust the message received and its bearer, and can identify the relationship between themselves and the warning originator:

“the capacity to identify issues and solutions during volcanic crises relies on dialogue and collaboration between scientists and those at risk.”^{xxi}

“in China what is important is much more the person and the institutions transmitting the message than the message itself” meaning that someone’s trust resides in the interlocutor and the institution this interlocutor belongs to and represents. In other words, the expertise and status of those producing and communicating information has prime importance. “^{xxii}

Hurricane Sandy, which badly impacted the north-eastern coastline of the United States in October 2012, provides us with a strong example of this.

The hurricane resulted in widespread storm surges and flooding, power failures, and deaths, particularly from drowning^{xxiii}. Sandy exposed many weaknesses in coastal defences, particularly including in the New York metropolitan area, where 97 people died despite all resources available to a forewarned, highly developed city. New York had been known to be vulnerable to such a storm surge^{xxiv}.

Sandy occurred after the establishment of popular social media platforms such as Twitter and Facebook, giving the opportunity to evaluate the usefulness of the platform. It was observed that people with a large likelihood of being impacted would engage more in disaster-related social media conversations such as preparedness and situational updates, which can be seen as a positive, but that socially vulnerable communities were digitally left behind.^{xxv} This highlights the importance of engaging in multiple media, using traditional platforms as well as personal connections.

One of the most well-known messaging examples using traditional relationships and platforms was the ‘personal plea’ issued by the Meteorologist in Charge at the Mt Holly, New Jersey office of the National Weather Service, Gary Szatkowski. Szatkowski took the unusual step of using his official, highly respected

position in the local community to include some emotive and unorthodox ‘cut-through’ messaging in briefings 32 hours before landfall, begging that residents evacuate if asked to do, and including his personal phone number to show his degree of concern:

“...If you are reluctant to evacuate, and you know someone who rode out the ‘62 storm on the barrier islands, ask them if they would do it again. If you are still reluctant, think about your loved ones, think about the emergency responders who will be unable to reach you when you make the panicked phone call to be rescued, think about the rescue/recovery teams who will rescue you if you are injured or recover your remains if you do not survive.

Sandy is an extremely dangerous storm. There will be major property damage, injuries are probably unavoidable, but the goal is zero fatalities.

If you think the storm is over-hyped and exaggerated, please err on the side of caution. You can call me up on Friday (contact information is at the end of this briefing) and yell at me all you want.

I will listen to your concerns and comments, but I will tell you in advance, I will be very happy that you are alive & well, no matter how much you yell at me”.^{xxvi}

Szatkowski’s actions showed an acute awareness of the importance of personal trust in warnings response and the likely reluctance of some to evacuate. He also showed a preparedness to take risks with his reputation and career by putting out such a direct message well in advance of landfall and is justly celebrated for this.

At a broader level, the example also highlights how early warning systems are often built and championed by passionate individuals, who may be involved in the work for their entire careers and beyond. The depth of commitment shown by individuals within the warning system, including a preparedness to ‘break the rules’ when circumstances justify it, makes a great difference to the performance of the system and the public perception of the integrity of the system. The same is true in agency relationships. Trusted and truthful relationships, including at the personal level, are vital when it comes to communicating the right information and making timely decisions.

Central European floods, July 2021: a chaotic, confusing deluge of information.

In mid-July 2021, more than 180 lives were claimed by floods caused by exceptionally heavy rain in Germany. Belgium also recorded more than 30 casualties, and Luxembourg, Netherlands and France also experienced heavy rain from the same weather system^{xxvii}. Intense public criticism of the warnings and responses in some countries began shortly after impacts commenced, with the main issues being inconsistent warning issuance and understanding, a lack of information, confusing information, missing information due to warning system infrastructure failure, and the compounding effects of major infrastructure failure and an ongoing pandemic (to the point where local COVID activists were reportedly trying to hinder rescue teams). Disbelief in flood level predictions was also a factor during the floods^{xxviii}.

At time of writing, analysis of the event is continuing, but it is clear that the challenge of timely, accurate communication over a complex area when flood waters are rapidly rising was a major problem, as it is for many fast-developing events. Events such as this will be expected to increase with climate change^{xxix}, and it is essential that our global capacity to deal with complex, compounding, and fast-evolving events is strengthened. This poses a quandary for design of local warning systems, as centralised information in such an event can be slow and inappropriate but delegated local authority (even where driven through trusted relationships as described earlier) can also lead to inconsistent responses^{xxx}.

It is possible to simultaneously have local, trusted relationships, and yet have a single, consistent, and rapidly updated ‘point of truth’ for all relevant warnings, but it requires early warning systems to work seamlessly across geographies, hazards, and time scales.

Driving good practice in multi-hazard, impact-based warnings

Thinking strategically through the challenges of early warning systems

Our short tour of case studies gives us a glimpse of the challenges in building better early warning systems. Although disasters disproportionately affect the marginalised (such as in the Bangladesh example), there is no part of the world immune from failures in early warning and early action, and there is no prospect that this will change in the foreseeable future. Globally, we are lagging behind our Sendai Framework commitments, including for early warning systems^{xxx}. Also from a project perspective, capacity development for early warning systems is frequently unsuccessful in practice for a variety of reasons, including lack of local ownership, short-term projects, a lack of long-term partnerships, and other sustainability-related issues^{xxxii}.

The complexity and scope of early warning systems means that no one individual, agency, or even government will have easy access to all the potential levers that can be pulled to improve early warning outcomes. This can be overwhelming - it is easy to either feel disempowered when looking at this big picture, or to ignore the big picture and dive in, only to realise later that our efforts have been misdirected.

However, the good news is that our efforts *can* make an enormous difference, as in the Mt Pinatubo example where a formerly unmonitored volcano progressed to an enormous eruption in a few short months with relatively low loss of life. And sometimes, changing just a single decision - slowing the Titanic down to avoid icebergs - can have powerful positive consequences. The challenges of implementing successful projects should not diminish the strength of our intent; rather, they should stimulate our strategic thinking.

So, where do we, as a warning community, start? How can we best translate early warnings into timely actions? One of the key questions to ask first is ‘where can we best work with others to make a difference?’ Having considered that from a strategic viewpoint, we can better use the large volume of literature and practical experience available to help in any early warning systems improvement project.²³ What follows here is a very short selection from the many measures that can be taken to better translate warnings into actions and desired impact. These examples are not intended to be comprehensive, but to illustrate simply that our thoughtful approach to early warning system development can result in positive outcomes.

Foundational, cross-cutting measures

Relationships and collaboration

Many early warning system projects begin with a technical idea or an amount to spend to ‘fix’ early warning problems. While capital investment is often helpful and necessary, it will be poorly spent if the foundational elements, including relationships, are not already in place or a core aim of the new project.

At the local level, early warning system relationships will usually involve multiple layers of government, many stakeholder groups, and key agencies (for example a hydrometeorological agency, a geophysical agency, and a civil defence agency, with many variations and complexities in arrangements). If, as a common example, some of those essential government agencies are fighting a ‘turf war’, then much effort may be needed to

² A ‘balanced scorecard’ type of approach could be considered to help develop a strategic view of where warning systems need strengthening to increase early actions. For example, the Alliance for Hydromet Development and World Meteorological Organization have developed the [Country Hydromet Diagnostics](#) tool and approach to assess the needs of National Hydrometeorological Services.

³ A range of Warning Briefing Notes and other reports relating to enhancing early warnings are available at [UCL’s Warning Research Centre](#).

obtain a spirit of cooperation and a true people-centred approach. Frequently, the situation will be more complex than that, even if we just consider the local level. Any effort to translate early warning into early actions must start with genuine commitment to strong, ongoing relationships, which take time and investment to build. The outstanding outcomes at Mt Pinatubo, for example, could not have been achieved without the respectful relationships in place^{xxxiii}.

In practical terms, it is also extremely unlikely that any effort to improve early warning systems will occur in isolation. There may be several different international capacity development projects on the books simultaneously for a single area, with communities and agencies seeking to benefit from these, but frequently frustrated by a lack of coordination at various levels, and (in the worst case) competition between external parties. This can create a large associated overhead for local agencies, alongside confusion and inconsistent guidance. Strong, collaborative relationships between external parties, and with local agencies, are essential for navigating through the inevitable conflicts and decision points in improving warning systems.

Like any relationships, early warning systems relationships need maintenance – repeated, regular liaison and consultation, genuine listening, and a preparedness to respond to evolving community needs, alongside changing personnel in associated organisations. Insufficient prioritisation of relationship creation and sustainment may frustrate any project to improve early warning systems, but if strong relationships are in place, everything else in early warning systems becomes achievable and possible.

Community empowerment

Any warning system should be inclusive of, and preferably ‘co-owned’ by the communities that it is designed to serve. In some situations, the warning can come from the community first and be delivered to the rest of the potentially affected populations. For example, at Mount Pinatubo, the signs of volcanic unrest were recognised *first* by the indigenous Aeta people, and reported to authorities through a civil society organisation. In that sense, the Aeta acted as the warning authority, as the responsible government agency initially had no monitoring in place^{xxxiv}. A sense of community co-responsibility is also strongly evident in the Hurricane Sandy ‘personal plea’ discussed earlier. The strong ‘first mile’ relationships necessary for an inclusive, empowering early warning system should be in place well before any crisis develops. Where they do not exist, they should be prioritised.

In empowering local communities, particular effort should be made to consider culturally and linguistically diverse and poor communities. These are typically considered more vulnerable to natural hazards, although many such communities also demonstrate strong resilience.^{xxxv} These communities are also typically underrepresented in emergency management and scientific agencies, which tend to have staff coming from ‘command and control’ type backgrounds (e.g. police, military) or from the science sector. Therefore, it is quite common to have chasms of perspective between warning agencies and potentially affected communities – and these chasms can inhibit trust and delay life-saving actions.



Sister Villages at Merapi volcano

Deadly pyroclastic flows, avalanches of hot rock, ash and gas, regularly sweep down Mt Merapi in Indonesia. To facilitate the evacuation of residents, a ‘Sister Village’ program has been initiated by local authorities, supported by UNDP. The program strengthens community resilience by pairing villages at high risk from being affected by an eruption with villages at less risk, where evacuees can be sustainably hosted, supported by procedures, evacuation routes, shelters, provision of food, training, and strong relationships. This is an innovative, participatory process and an excellent example of community empowerment. Webcam image courtesy Magma Indonesia via the [Global Volcanism Program of the Smithsonian Institution](#).

The Pinatubo example of warning response also reinforces the importance of practical warning response strategies. If evacuation is impractical, less people will evacuate, so supporting measures are needed such as the ‘sister villages’ set up at Mount Merapi, Indonesia^{xxxvi} (see inset box).

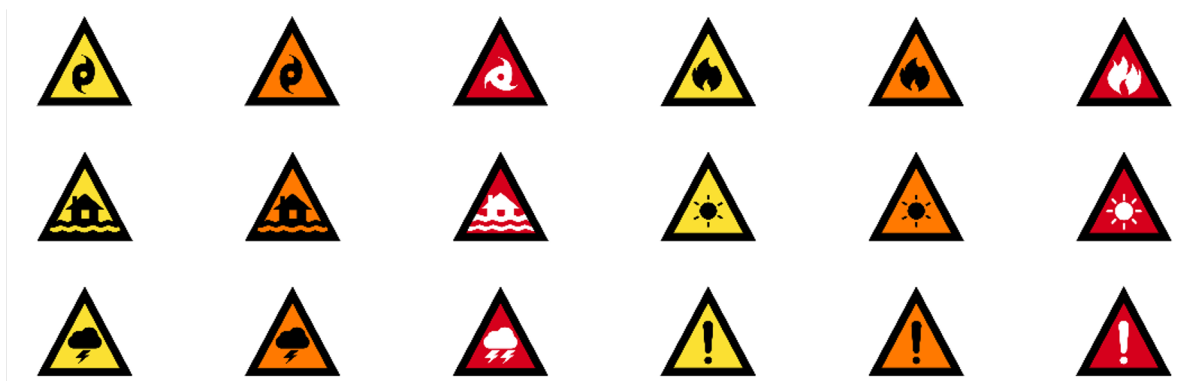
Civil society organisations have a large role to play in these cross-cutting spaces, as they tend to form a large part of the ‘glue’ that holds communities together, and hence are skilled at advocating for user-centred, relationship-based, and culturally and linguistically diverse approaches^{xxxvii}.

A multi-hazard approach

Creating consistency and clarity to integrate warnings

Most people live in multi-risk or multi-hazard environments where decision-making during compound events is particularly complex. Therefore, it is vital that the warning system takes a multi-hazard approach and that this extends to community level. Nobody has time or headspace to work with multiple different warning systems, particularly when those hazards are compounding: a tsunami warning system must ‘speak to’ a tropical cyclone or volcanic warning system, in a way that encourages and empowers affected communities to employ a combination of strategies that maximize resilience across sectors.^{xxxviii}

The work to implement this multi-hazard approach should be allowed for in projects. Typically, early warning systems evolve from specialist communities dealing with separate hazards, resulting in inconsistent approaches across disciplines and across borders. Communities and key individuals are usually well invested in those systems, through their hard work creating, building, and embedding the systems. Reconciling system differences and evolving to a seamless multi-hazard approach requires a major commitment of time and diplomacy and requires years and strong government sponsorship and leadership. It is, however, work that is intensely worthwhile, and the process itself can be used to bring emergency management partners closer together and closer to the community.



The hard work to make warning systems work for the people

Australia has been undertaking an intensive process to create a multi-hazard, multi-jurisdiction [warning approach](#) across internal borders and agencies. The result is a coherent system of warning levels, calls to action and signage that for the first time gives a seamless, locally relevant system for the Australian public, implemented in 2022. Images: Australian Government

Since most early warning systems have their roots in single-hazard systems, the work to integrate these into multi-hazard systems might take many years and include a strong emphasis on working across disciplines and jurisdictions.

Risk knowledge measures

Identifying key hazards: a good opportunity for intergenerational conversations

Hazard identification projects are good vehicles for community engagement, particularly around hazards that are infrequent but devastating. A community conversation around, for example, ancient tsunamis or eruptions, can lead to the seamless incorporation of traditional knowledge and new science into impact-based warning systems, and better decision making when an event does occur. Even in the ‘personal plea’ example of Hurricane Sandy, there is an explicit appeal to intergenerational knowledge with a reference to an event 50

years previously. Projects that blend science with community memory provide the ability to translate warnings into actions when the next big event comes along.

The devil in the details – working to refine risk information

The community might rightfully assume that emergency managers have all of the information that they need to keep the population safe. This is never the case. Often, simple physical factors (such as coastal bathymetry) are not well-enough known. A volcano may have no hazard map. Stakeholder relationships can be poorly defined. Critical infrastructure may not be mapped for exposure, and risk information might be unconsolidated or unavailable. At all levels, it is critical that the gaps in risk knowledge are closed, and preferably under an ongoing, stable program that continuously improves information in the gaps between hazardous events.

Monitoring and warning measures

Obtaining and integrating data is vital for effective warnings

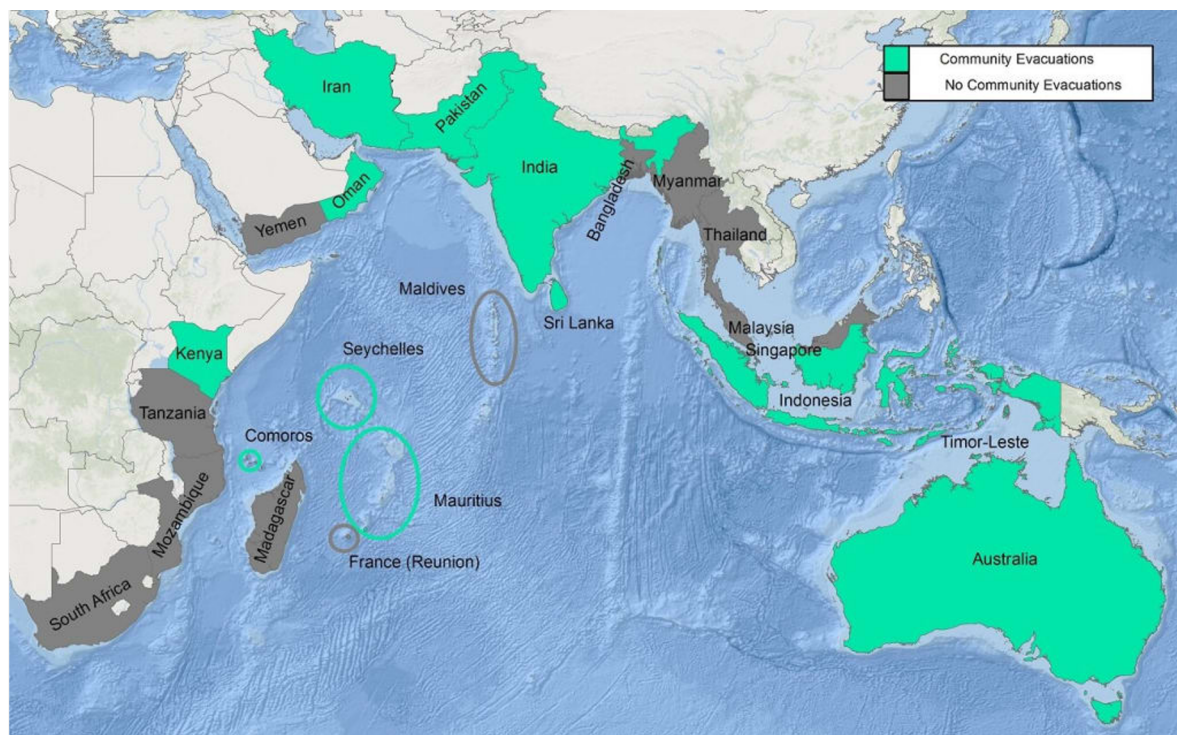
Enormous advances in science and technology have now made long lead times possible for many hazards, meaning that anticipatory actions can be taken with more confidence and earlier than previously. But the implementation of this science into operations lags far more than it should. In the highly organised world of hydrometeorology, there are still large gaps in observations networks, and in data sharing from those networks. Many capacity development projects create local observations, but do not ensure that those observations are connected to global networks, greatly reducing the usefulness of those projects. New approaches are being developed that judge the worth of observations not on how many observations are taken, but how many are shared with the world.^{xxxix}

In some fields, there is much less organisation and no clear mechanisms to drive progress. For example, Mount Pinatubo in 1991 was not monitored seismically, but neither was Hunga Tonga-Hunga Ha’apai in Tonga prior to its massive eruption in January 2022 – an eruption that destroyed communications networks and created an ocean-wide tsunami. It should not be acceptable to any community or region that any potentially active volcano is unmonitored, but poorer nations cannot carry that burden alone and there is currently no United Nations body taking responsibility for the issue, making progress difficult^{xl}. United action is needed to ensure that hazards such as geohazards are looked after on an organised, multilateral basis.

Successful investment in these areas, particularly on an ongoing basis, typically brings a benefit to cost ratio of the order of 10:1^{xli}. Non-government agencies can assist this investment by continuing to highlight the needs of the community for accurate warnings and by helping to ensure that the international, regional, national, and local elements of the warning process are visible to everybody.

Improved preparedness and response capabilities

The importance of testing warnings via exercises



Coordinated simulation exercises – disaster preparedness at a large scale

The Indian Ocean Tsunami Warning System, developed since the devastating 2004 Indian Ocean earthquake and tsunami, holds regular, coordinated exercises across the ocean basin, named 'IOWave'. 24 countries participated in the 2016 exercise, with many of those countries practising community evacuations as part of the exercise. Coordinated efforts such as this help to test systems at international, national, and local scales, increasing the probability of response actions during real emergencies. Image: ICG/IOTWMS

Rapidly developing and confusing warning situations, such as for the European floods of 2021, can quickly turn into disasters if the community is not prepared and organised well in advance – it is far too late to prompt effective actions without long term preparedness measures, including plans and standard operating procedures. This should include regular exercises that extend to community level, such as in the successful series of Indian Ocean tsunami preparation exercises, IOWave (see inset box).^{xliii} These sorts of large-scale exercises are a significant undertaking, but result in better-prepared communities who are more ready to take action.

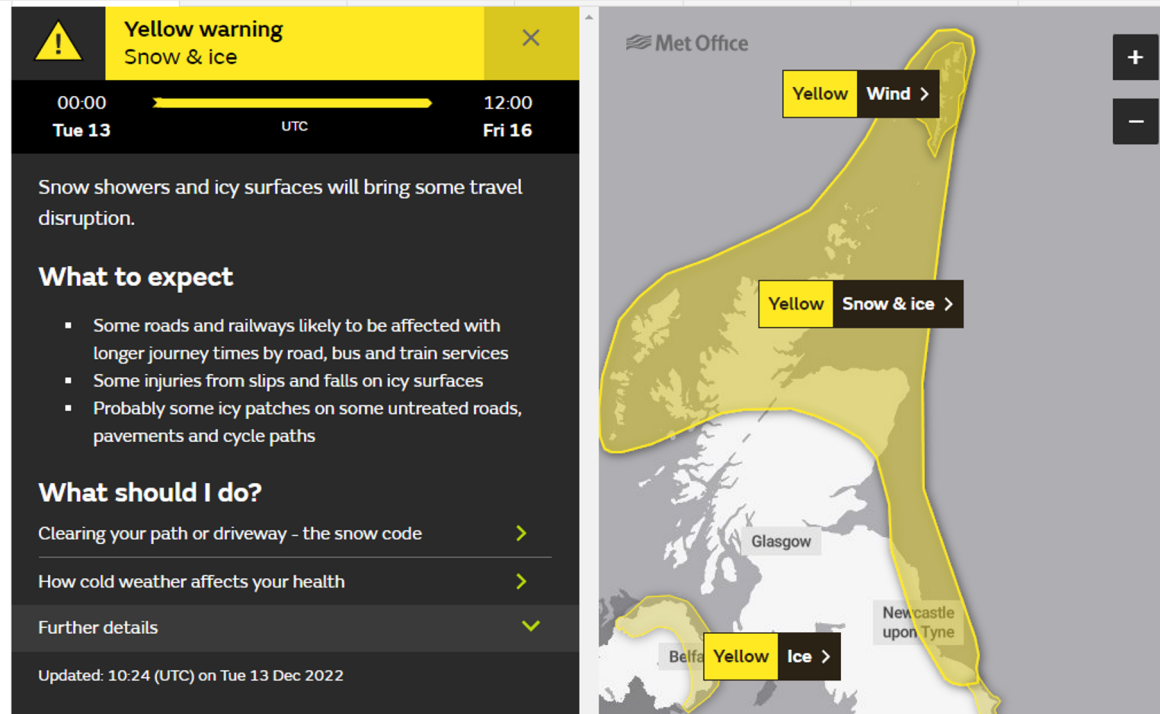
Preparedness and response measures are particularly important for long-period hazards such as geohazards, the more extreme hydrometeorological events, and rarer events such as pandemics and solar storms. Ideally, these should be undertaken on a multi-hazard basis.

Enhanced communication measures

Impact-based forecasts and warnings: a big step forward

Impact based forecasts and warnings represent a significant change in thinking. An impact-based warning changes the emphasis in the warning from 'what the hazard(s) will be' to 'what the hazard(s) will do'⁴, bringing large benefits due to increased user understanding of risks and impacts.

However, this shift in thinking requires significant support for filling research gaps and for implementation, including a careful design for individual users, and supporting information about impacts^{xliii}. Few countries have the capacity to make this shift quickly and comprehensively without assistance, but the ongoing benefits for the community are large, with additional side-benefits of closer relationships between communities and warning agencies. Any impact-based warning implementation should be designed to be sustainable and proportionate to country resources, so that benefits can be realised immediately in the communities concerned.



The image shows a screenshot of a UK Met Office weather warning interface. On the left, a yellow banner at the top reads 'Yellow warning Snow & Ice'. Below this, a timeline shows '00:00 Tue 13' to '12:00 Fri 16' in UTC. The main text states: 'Snow showers and icy surfaces will bring some travel disruption.' Under the heading 'What to expect', there is a bulleted list: 'Some roads and railways likely to be affected with longer journey times by road, bus and train services', 'Some injuries from slips and falls on icy surfaces', and 'Probably some icy patches on some untreated roads, pavements and cycle paths'. Under 'What should I do?', there are three links: 'Clearing your path or driveway - the snow code', 'How cold weather affects your health', and 'Further details'. The bottom of the text panel says 'Updated: 10:24 (UTC) on Tue 13 Dec 2022'. On the right, a map of the UK shows yellow warning areas over Scotland and Northern Ireland. Callouts on the map include 'Yellow Wind', 'Yellow Snow & ice', and 'Yellow Ice'. City labels like Glasgow, Belfast, and Newcastle upon Tyne are visible. The Met Office logo is in the top left of the map area.

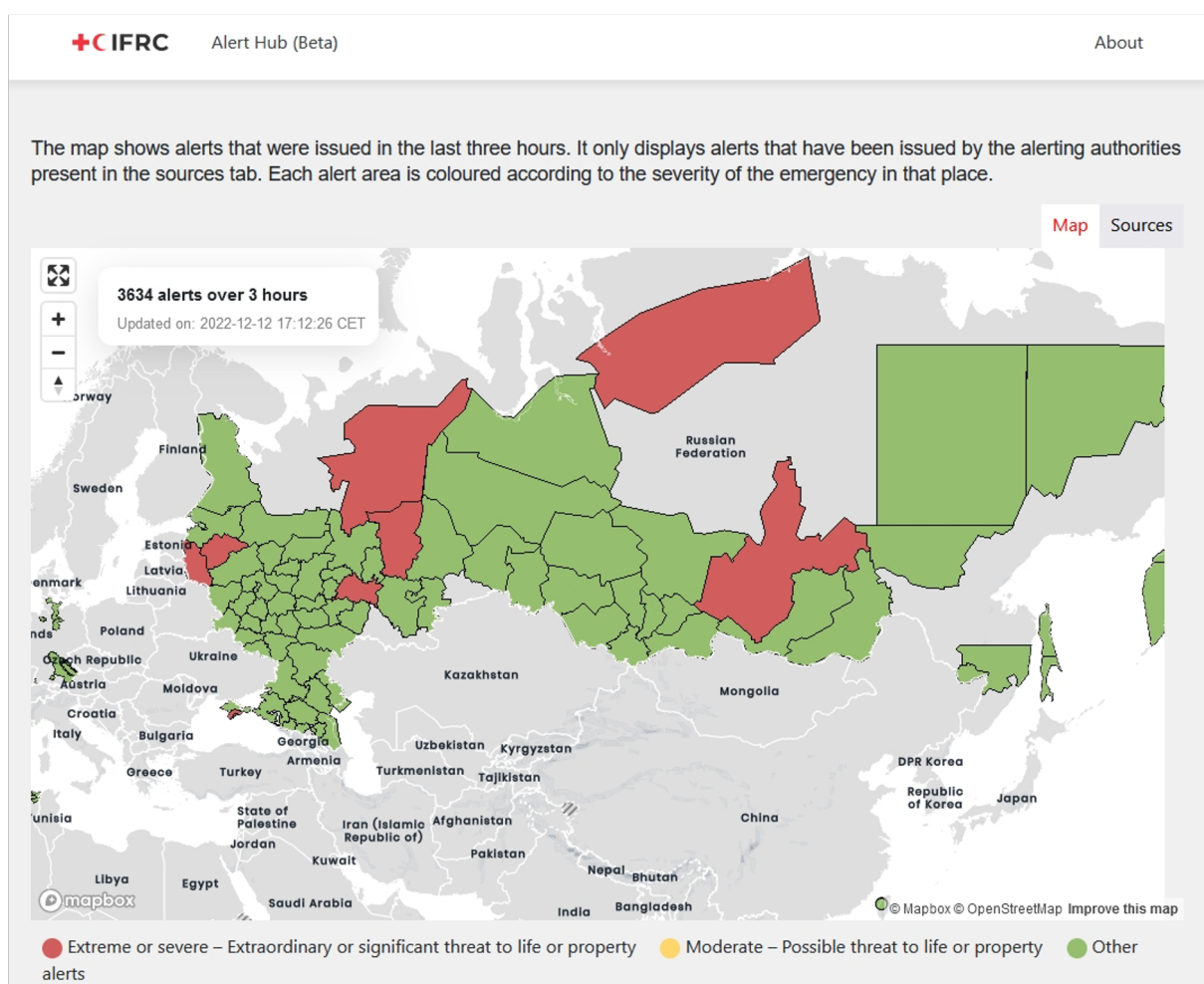
Impact-based warnings – helping to guide the right actions

Many countries are implementing impact-based warnings. In this example from the UK Met Office, the warning shows a clear narrative from a description of the hazard to practical steps that can be taken, with links to further information. Image: UK Met Office.

⁴ Guidelines on Multi-hazard Impact-based Forecast and Warning Services have been published by the World Meteorological Organization, with an emphasis on the hydrometeorological perspective. See <https://public.wmo.int/en/media/news/impact-based-forecasting-informs-anticipatory-action>

The Common Alerting Protocol: creating a common ground

The Alert Hub – demonstrating the potential of the Common Alerting Protocol



The International Federation of Red Cross and Red Crescent Societies is developing the Alert Hub, showing warnings issued by relevant authorities in CAP format over the world. There is currently a gap between countries that have some CAP capabilities (most countries in this sample), and those that are actively issuing alerts (in this example, notable risks existed at the time in some of the grey areas, such as in central and eastern Ukraine). However, it is feasible to leverage CAP for multi-hazard or all-hazard alerting across the world, reflecting consolidated risk to lives and property rather than selective hazards.

A key initiative to increase and diversify the communication of consistent warnings is the Common Alerting Protocol, or CAP. The CAP standard is a way to distribute consistent, structured warning messages rapidly across a number of different communication channels, such as radio, television, telephone, Internet and emergency sirens. As for the impact-based forecasts and warnings, guidelines on CAP implementation exist. Implementation itself takes some resources⁵, but CAP can be implemented in a 'learn by doing', incremental approach. With sufficient support, CAP alerts can be thoroughly operationalised so that communities, government decision-makers, and third parties have confidence that multiple relevant hazards are covered and that a consolidated feed of CAP-based information accurately reflects risks.

The investment in CAP is well worth it. Warnings broadcast using the CAP can be rapidly shared, updated, and put against other information in a consistent and useful manner. The format is also particularly suited to

⁵ [Guidelines](#) for implementing the Common Alerting Protocol are available from the World Meteorological Organization

carrying graphical material for rapid assimilation by communities, and for use at the community level (for example, by local authorities and community radio stations). Third party information providers, including media, civil society organisations, can also easily repackage the information accurately and update with each new warning.

The CAP is an essential underpinning for any approach that will successfully handle the chaos of any fast-developing situation such as the Central European floods of 2021. Also, although the implementation of CAP has been driven initially from the perspective of natural hazards, the approach easily extends to an all-hazards approach such as for health emergencies, or armed conflict, giving a more holistic view of community risk (see inset box).

Media and social media relationships

Good media and social media relationships are essential for underpinning the technological advances of CAP and other distribution and communication methods. The rapid development of social media platforms has required adjustment from warning agencies, who have had to adapt quickly to the need to have relationships with users through multiple channels. These media are also where the tight relationships between agencies (including the civil society sector) need to be evident, in order to mutually support the right decisions and actions by affected communities. As discussed earlier, these relationships need to be maintained and regularly refreshed.

Also, as discussed in the Hurricane Sandy example, social media is not a substitute for other means of communication. Particular care has to be taken to communicate with marginalised communities and individuals, in whatever form and language works best for them.

Taking Action

From this quick tour of early warning systems, it is clear there are many good ways to improve the actions taken and to save lives and property. Whether we as a community are helping communicate better, improve warning accuracy, empower communities, or research hazards, we all have parts to play. A strategic, thoughtful approach can help us to make a positive difference.

Our challenge is to understand that nothing we do fixes everything by itself. The improvement of early warning systems, and translating those warnings into actions, will continue to be a collective effort over decades to address what may seem overwhelming levels of complexity. Nevertheless, we have opportunities to work with other to make the whole big picture better, and new opportunities will continue to present themselves. If we work successfully, we can get better information for decisions making to the people who need it, earlier, more clearly, and more usefully. We may be enabling a ship's captain to slow down in bad weather, or helping a family make a decision to evacuate, or assisting relief supplies in getting to the right place more quickly – whatever we do, if done collaboratively, respectfully, and appropriately, will be helping to save lives and protect property. The work is worthwhile.

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