Brochure

Early Warning Systems

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Cooperación Suiza
en América Central

Sendai Framework for Disaster Risk Reduction 2015-2030
Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better".

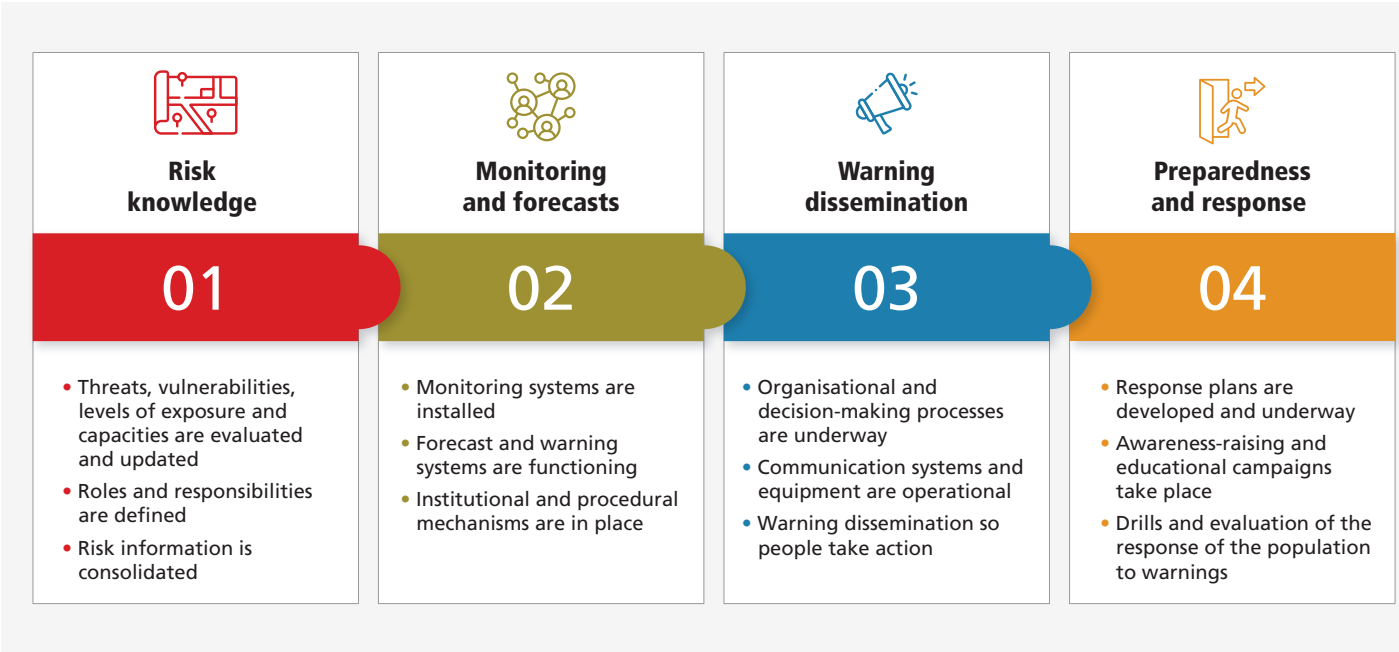
The ***Disaster Risk Reduction Programme (DRR Programme)*** is one of SDC's most emblematic achievements in Central America. It began in 1999 in the wake of Hurricane Mitch with projects in Honduras and Nicaragua, was later expanded to include El Salvador and, finally, the entire Central American region. More than 1.5 million persons benefitted directly and at least 19 million did so indirectly. With participation from a variety of partners, almost seventy projects were implemented from 1999 to 2024. These were structured along six **thematic lines:**

- **Natural hazard mapping and local risk management**
- **Early Warning Systems**
- **Integration of DRR and CCA into universities**
- **Construction of safer housing and infrastructure**
- **Strengthening of national and regional DRR systems**
- **Incorporation of DRR and CCA into other SDC projects**

Five projects, both bilateral and regional, were carried out under the thematic line *Early Warning Systems (EWS)*, to which end 9% of the budget was allocated, equivalent to almost CHF 4 million. The Swiss Agency for Development and Cooperation (SDC) decided to invest in this type of project because Central America is one of the places with most seismic and volcanic activity in the world. There are 27 volcanoes distributed along the Central American arc, some of which are considered to be among the most active on the planet. At least 19 million persons live in areas of high seismic and volcanic risk. The countries with the highest levels of threat from these are Costa Rica, El Salvador, Guatemala and Nicaragua.

EWS:[1] is a comprehensive system established to monitor risk. It provides timely and effective information on foreseeable threats. The purpose of an EWS is that the pertinent institutions, key actors and the population at large act quickly and take the necessary actions to avoid or reduce risks, and prepare for an effective response.

Components: a complete and efficient EWS has four key components,[2] as shown in the graph below.



[1] Definition given by the UNDRR Office.
[2] Platform for Early Warning Promotion, ISDR -UN, 2006.

Types of EWS and projects: EWS detect and issue warnings regarding earthquakes, volcanic eruptions and tsunamis in different ways. Earthquakes cannot be predicted, although it is possible to register their seismic waves, if only seconds before the strongest and most dangerous shocks, as these travel at higher speed. Tsunamis are detected before destructive waves reach the shore and is therefore possible to warn people. In the case of volcanic eruptions, early signs can be detected, sometimes weeks or even months beforehand.

According to estimates made by the Swiss Federal Institute of Technology Zurich (ETH Zurich), and based on the experience of the *DRR Programme* in Central America, to install a functional and operational EWS for earthquakes in the entire region would require a continuous, ten-year intervention and cost approximately CHF 5 million, not including the building of seismic networks, which is prior condition to installing the EWS.

An EWS for volcanic eruptions, again taking the *DRR Programme* for a reference, requires at least five years and approximately CHF 500,000 for implementation. This sum may vary depending on the technology and amount of equipment to be used.

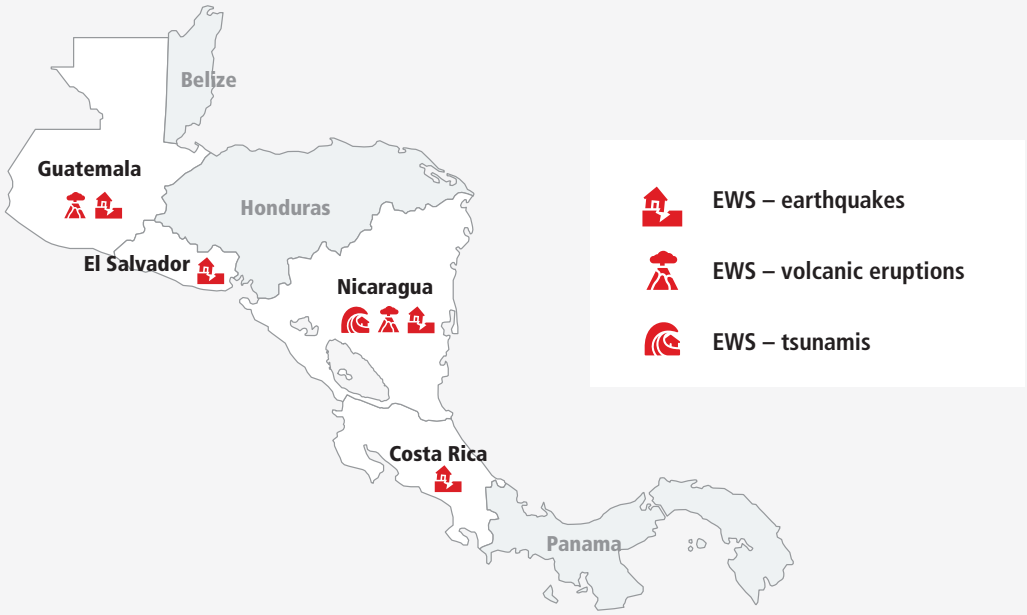
The projects under this thematic line concentrated on the following key components: **1. Risk knowledge**, **2. Monitoring and forecasts**, **3. Warning dissemination** and **4. Preparedness and response capacity** .

Early warning system for earthquakes in Central America. Regional. Implementing agencies: Federal Institute of Technology Zurich (ETH Zurich) and the Foundation for Academic Development of the National University of Costa Rica (FUNDAUNA). Three phases: 2016-2023. SDC contribution: CHF 2.2 million.

Early warning system for volcanic eruptions in Guatemala and disseminated in Central América. Regional. Implementing agencies: Asociación Vivamos Mejor Guatemala, ETH Zurich and the Geosciences Centre at the National Autonomous University of Mexico (CGEO-UNAM). Single phase: 2019-2023. SDC contribution: CHF 1.6 million.

Awareness-raising, organisation, and early warning to reduce vulnerability to tsunamis on the Pacific Coast of Nicaragua, with emphasis on the municipality of San Rafael del Sur. Nicaragua. Implementing agency: Nicaraguan Red Cross. Single phase: 2006-2007. SDC contribution: CHF 136,000.

Early Warning Systems in the countries



Impact hypothesis

When an early warning is effective, people have time to get to safety, and this saves lives.

It is possible to reduce the loss of human lives when capacities are strengthened at those national institutions, which are able to build and manage an EWS. Further, scientific knowledge concerning threats is improved, as is the seismic and volcanic network detecting and monitoring capacity, and information between the various institutions is systematically exchanged.

It is also important there be good governance to manage and operate each EWS. This implies that each actor knows their functions, roles and responsibilities; that human and financial resources are available to operate them, and that there is a legal framework for their institutionalisation. In addition, there must be standard means, procedures and protocols for operating the systems, facilitating the decision-making process and issuing timely warnings. The population, once organised, aware and informed regarding risks has the capacities needed to act when it receives the warning and will move to safe places following established and tested evacuation routes.

Objective

Contribute to strengthen capacities at national institutions to establish and operate Early Warning Systems that issue timely warnings to the population and, that the latter knows what actions to take to safeguard their lives.

Swiss added value

The EWS for earthquakes and volcanic eruptions both involved the transfer of technology and specialised know-how from Switzerland to Central America, as well as the enrichment of scientific knowledge concerning threats through technical studies and efficient seismic network management. The EWS for earthquakes was developed in Switzerland, for Switzerland and then was transferred to Central America in 2016 by ETH Zurich experts. The quality of network management was improved in order to optimise the systems. These initiatives have the potential to establish more lasting and sustainable collaboration in the future between scientific institutions in Central America and Switzerland. As for the tsunami EWS, Nicaragua benefited from Swiss expertise, as the earlier experience with the *Disaster Prevention in Nicaragua Programme (PRENICA)* was brought to bear and actions concentrated on awareness-raising, to ensure the population learnt how to look out for signs of a tsunami and the actions to be taken. It also included the installation of sirens in the coastal village of Masachapa.

Innovation

The earthquake EWS is innovative, as it uses high-quality specialised technology that can be adapted to the features of each of the four countries in the region. Furthermore, it is far less costly than the original system in Switzerland, which makes it an accessible tool for developing countries. As for the EWS for volcanic eruptions, the equipment used was, again, of high quality but low cost. It covers the four EWS components in a comprehensive manner, has a robust scientific foundation and is the first integrated system ever installed in Guatemala. The EWS for tsunamis was the first one developed and implemented in Nicaragua and Central America. Later on, several of its components were replicated in additional vulnerable communities on the Pacific Coast, with support from other donors.

Stages

In order to develop EWS for earthquakes and volcanic eruptions, it is necessary to traverse the following three stages:

Stage 1
EWS feasibility and design (2 years)

Objective: Evaluate the feasibility of installing a warning system, the methods to be used and most suitable type of seismic and volcanic network.

Main activities:

- Undertake a diagnostic of the existing network, equipment, location and functioning (seismographs, accelerographs, etc.), information filing mechanisms, processing and data dissemination. It is also sought to understand needs and existing EWS capacities.
- Make the necessary improvements to existing networks, so these can develop EWS.
- Develop a prototype of second generation EWS software module for earthquakes (2G VS (SC3), install and test its functioning when sending warnings.
- Design a monitoring system for the EWS.
- Undertake scientific studies and make maps in order to better understand the threats and vulnerabilities.

Experts in volcanic risk management show a map indicating the location of monitoring stations to local coordinators in the community of San Marcos Palajunoj, Quetzaltenango, Guatemala. © Asociación Vivamos Mejor, Guatemala

- Define EWS priorities, taking into account the dangers it is to focus on, the threat levels, and human and financial capacities.

In this stage it is crucial to have available specialists at national institutions that are available to participate in the process and be trained so they understand how the EWS functions and are therefore in a position to operate and maintain it. It is likewise important to ensure there is institutional commitment, so staff turnover is low among those running the system, and sufficient funds are allocated to make improvements to the networks.

Stage 2
Warning system in the demonstration stage (2 to 3 years)

Objective: Demonstrate that the seismic network system works properly, identify needed improvements and make them continuously.

Main activities:

- Evaluate the warning dissemination.
- Establish or improve protocols for the warning dissemination, identify and test the channels used on an experimental basis with key actors.

- Consider the possibility of replicating the system in other interested countries that have similar capacities as those of the pilot country. In such a case, the process begins with a feasibility study and the installation of the validated prototype (stage 1).
- Strengthen capacities for preparedness and disaster response in the municipalities and communities at highest risk, in coordination with civil protection entities.
- Carry out awareness-raising and communications activities so the population and different actors know what to do once they receive the warning.

Specialist in vulcanology reviews and adjusts a multiparametric station. El Palmar, Quetzaltenango, Guatemala. © Asociación Vivamos Mejor Guatemala

In the case of the *DRR Programme* and the *Early Warning Systems for Earthquakes Project*, the pilot country was Nicaragua. It was then extended to Costa Rica and later to El Salvador and Guatemala. In the first three of these, the warning dissemination was successfully tested using digital television and cell phones.

Stage 3

Operational warning system and governance (2 to 3 years)

Objective: Consolidate EWS and system governance at all levels.

Main activities:

- Ensure warnings are sent to the population via the channels established.
- Evaluate the warning dissemination to the population and make any needed improvements.
- Implement education and awareness-raising programmes aimed at the population so they understand how it works, including the possibility of false alarms, in order to bolster the credibility of the EWS.
- Strengthen data processing, communication channels and the monitoring of warnings issued.
- Routinely fine-tune and test protocols, decision-making procedures and the warning dissemination.

A specialist at the National Coordinator for Disaster Reduction (CONRED), explains the pyroclastic flow risk map to local authorities, as part of the evacuation drill for volcanic eruption. Municipality of San Sebastián, Retalhuleu, Guatemala. © Asociación Vivamos Mejor Guatemala

Sustainability

In general, sustainability is classified as moderate, considering there is trained and specialised personnel in place and a budget has been negotiated with which to complement the equipment and processes, thanks to synergies with other organisations. In addition, collaboration agreements were reached with scientific entities in several countries to continue the technical accompaniment. However, it is necessary to strengthen system governance and ensure the involvement of all actors and entities that have mandates or roles to play in issuing warnings. The idea is that these provide the needed human and financial resources to keep the EWS operational once foreign financing and technical accompaniment draw to a close.

Resources

The projects require a technical team and a person charged with coordination. On the team must be staff specialising in geology, seismology, vulcanology, electronics and network management, among others, all with experience in EWS. Ideally, partners should have the capacities and administrative staff needed to ensure accountability, project follow-up and effective resource administration. **Reference cost:** CHF 400,000 per year.

Implementation options

The projects should be implemented by the national governing entities responsible for monitoring threats and warnings, in very close coordination or joint implementation with civil protection entities that have a mandate to issue warnings. However, it has been the experience of the *DRR Programme* that this was not possible due to difficulties some entities faced when it came to signing international cooperation agreements. For this reason, in the case of the EWS for volcanic eruptions, the implementing agency was the *Asociación Vivamos Mejor Guatemala*, in close collaboration with the National Seismology, Vulcanology, Meteorology and Hydrology Institute (INSIVUMEH) and the National Coordinator for Disaster Reduction (CONRED). The EWS for earthquakes was implemented by ETH Zurich, which has the experience needed to develop the system: A contract was signed with FUNDAUNA to administrate the budget for local activities.

Success factors

1. The existence of services and national seismology and volcanology networks, made up of professionals trained in several fields of science. This became the foundation for establishing the EWS. Good collaboration and trust was established between the implementing agencies at the projects and the various actors involved at regional, national, municipal and community levels. This trust was based on frank and transparent communication, as well as on the acknowledgement of and respect for the roles of each actor.
2. The selection of organisations to carry out the project which enjoyed considerable credibility and prestige in their respective fields served to keep the projects coherent and adapt them to their contexts, thus ensuring the quality of the results achieved.
3. The cooperation and exchange of experiences and information between operators of seismic networks in the countries grew stronger over time, making them more efficient by sharing mutual experience and using information made available by other seismic networks in neighbouring countries.

Poster used during an awareness-raising campaign among communities living on the Pacific Coast of Nicaragua. © COSUDE

4. The use of the same software (SeisComP) in all countries. Switzerland facilitated its adaptation and development in a relatively short period of time and at low cost.

5. The alliances forged with the Japanese International Cooperation Agency (JICA), Japan Telecommunications Engineering and Consulting Service (JTEC), the Geosciences Centre (CGEO) at the National Autonomous University of Mexico (UNAM), civil defence institutions, the Nicaraguan Red Cross and the Nicaraguan Institute of Territorial Studies (INETER), allowed for accelerating the warning dissemination to the population by means of digital television and to achieve greater reach for the awareness-raising campaigns regarding tsunamis. Furthermore, the alliances with universities, specialised scientific institutions, and volcano observatories allowed for improving the quality of the EWS, exchanging experiences and increasing knowledge among local experts.

Main challenges and lessons learnt (LL)

1. Local specialists participated only partially in the generation of the EWS software for earthquakes, among other reasons because specialised basic knowledge was required. Likewise, the training didn't go deep into the matter. This means replication without support from ETH Zurich may prove problematic.

   LL. During the diagnostic stage, capacities and competences of human resources must be verified, including knowledge of the English language. It is also necessary to prepare training plans to manage the EWS and eventually replicate them.

2. Ensure the EWS are sustainable without a policy framework by which to institutionalise them, with limited competent staff and insufficient financial resources available for equipment maintenance and replacement.

   LL. Strengthening EWS governance must begin from project outset. The later involvement and taking of ownership occurs, the more difficult it will be to institutionalise the processes and systems. In the case of warning systems with regional coverage, CEPREDENAC could play an important role in governance and the coordination between technical and civil protection entities, so the warnings reach the population through standard procedure and mechanisms.

3. Availability of financial and human resources to develop longer-term awareness-raising processes.

   LL. Awareness-raising processes require sustained actions, beyond only a campaign in the context of projects. It is important to institutionalise and undertake them on a permanent basis, with resources from institutional budgets.

4. National institutions face difficulties to acquire and import specialised equipment for the EWS due to unfavourable legal frameworks, a scarcity of providers, and the internal bureaucracy.

   LL. The agreements must include specific clauses on institutional commitment to ensure smooth equipment procurement and customs clearance. Furthermore, donors must be informed of institutional restrictions, so they can seek options together and ahead of time.

5. Increase the social acceptability of early warnings and reduce the occurrence of false alarms, in an effort to raise levels of trust and credibility of the population regarding the EWS.

   LL. False alarms cause no serious concern among the population in the countries, but it is important they be held to a minimum because they may place the credibility of the system at risk. The population should be told when an alarm was false.

6. Lower coverage of digital television in rural areas reduces the effectiveness of warning dissemination to those sectors of the population that need them most.

LL. The projects need to incorporate strategies that combine a variety of channels for communicating warnings, such as SMS messages by cell phone, digital TV, radio and sirens, in order to ensure better dissemination, including in rural areas. The language used must be easy to understand, avoiding technical terms and formats which are not appropriate for the population at large and community organisations, who need to react in a timely manner.

Good practices

1. Building on experience and an EWS infrastructure and using systems already existing in the countries ensures sustainable development and increases access.
2. Place at the disposal of national EWS implementing agencies specialised in technical backstopping to accompany the process and provide technical inputs that contribute to good quality, adequate knowledge and technology transfer, and capacity strengthening among local specialists.
3. Utilise the open code software available to the public.
4. The use of similar databases, processing centres, seismic warning software and dissemination frameworks in each of the countries contributes to their functioning as backup systems.

> “Our community now knows what risks we are exposed to. We also know what to do to protect our lives when the volcano erupts. We have not only the know-how, but also the tools and material needed to support possible evacuation measures. It is also crucial that our community is now organised to lead and guide others in case of disaster”.
>
> **Mirna Elizabeth Martínez López,** director of the Local Disaster Reduction Committee, village of Las Marías, El Palmar, Quetzaltenango, Guatemala.

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