TECHNICAL BRIEF

INTERMEDIATE CLIMATE INFORMATION SYSTEMS FOR EARLY WARNING SYSTEMS

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Summary

New communication technologies, free software and hardware to improve Early Warning Systems for floods and landslides, using a participatory approach in coordination with the authorities. That is to say, under an intermediate or appropriate technology approach.

This document shows the pilot experience carried out by Practical Action in partnership with the population, the municipality of Lurigancho-Chosica (Lima-Peru), the Korean International Cooperation Agency – KOICA and the National Civil Defence Institute

Photo 1. Early version of a monitoring station installed in Chosica, Lima - Peru.

Keywords

Early warning system, resilient technologies, floods and related hazards, prevention, risk management, monitoring, Arduino, Raspberry Pi.

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Problem

Early Warning Systems (EWS) stand out among the non-structural measures to prevent the loss of lives during floods and landslides. EWS can be defined as the group of measures and skills required to generate and disseminate useful and timely information to enable people at risk to prepare themselves and act appropriately, with enough time to reduce potential damages or losses (UNISRD, 2009).

In order to be effective, they must cover 4 components operating in a coordinated manner: (1) knowledge of the risk, (2) monitoring and warning, (3) dissemination and communication, and (4) response capacity [for more details on EWS, review the document "The Early Warning System for floods linked to the El Niño Phenomenon"]. However, EWS sometimes have a limited impact because technological, community and organizational aspects are separate, especially in components 2 and 3.

This segmentation can cause problems, such as the lack of useful hydrological information, its untimely distribution and the lack of communication channels between response entities. Furthermore, because of the usually high purchase and maintenance costs of climate monitoring stations, the number of stations installed is insufficient for nationwide monitoring.

This document contains a technological solution to respond to problems of this type, seeking to combine it with community and organizational aspects.

How To

Step 1. Study of the current situation and gaps for implementing an Early Warning System

The first step consists of identifying needs and strengths in relation to the four components of EWS, gathering both technical information and local knowledge. This identification must be combined with the work aimed at strengthening the community, using participatory technologies. As regards the study described in the following section, climate information was one of the gaps identified, which could be addressed by a technological solution. We found out that there were variables that were not being measured, areas that were not being monitored and information that was not being processed; also, that although maximum historical events were registered in the collective memory, there were few robust data. These problems can be addressed with technological solutions, so step 2 consisted of mapping the different types of technologies available today.

Step 2. Mapping of technological solutions to solve the problem identified in step 1

In recent years, new possibilities have been opened for mass use, low cost and open technologies. On the one hand, the mass use of communication technologies has resulted in almost total connectivity, providing the opportunity for direct communication, in real time, between various organizations and with the most vulnerable people, using the cellular network (GPRS), wireless networks or radiofrequency systems (RF).

On the other hand, due to developments led by free software and hardware communities, affordable technological tools can be obtained, as well as the freedom to adapt them to specific contexts, thus allowing for systems to be designed according to local needs. For example, 3D printers, low cost microcontrollers and microcomputers like Arduino and Raspberry Pi, or open source web platforms.

These tools facilitate the development of intermediate or appropriate technologies, i.e. of the scale required, decentralized and focused on people. In order to attain an effective Early Warning System and after identifying the gaps (step 1) and the technological possibilities (step 2), the next step consists of designing appropriate solutions.

Photo 2. Current version of a monitoring station.

Step 3. Design of monitoring stations that respond to the needs, based on the technological solutions identified. First of all, the need for ideally modular and low-cost monitoring stations was proposed, either to determine variables that are not being measured, or to cover unmonitored areas with conventional hydro-meteorological variables. Secondly, it was proposed to link these stations to a climate information system that can manage and process data, in addition to sharing processed information among the authorities, including warning levels between local authorities and the vulnerable population.

On that basis, an intermediate climate information system was developed referred to as *Qawaq* ("the one who looks" in Quechua), to provide technological support for EWS for mudflows or *huaicos*[1] and floods.

Some of the technical details of the current version of *Qawaq* describe its operation under the paradigm of The Internet of Things. For collecting and sending data, it uses a Wireless Sensor Network (WSN) controlled by low-cost microcontrollers and microcomputers like Arduino and Raspberry Pi, connected through the cellular network (GPRS) and with local links through Radiofrequency (RF) modules. For data and information management, it uses a number of free web platforms, some of them open source, that allow multi-directional communication between stations and the people responsible, whether local government officials or community leaders, as well as conventional instant messaging platforms like WhatsApp or Telegram. Lastly, both the web platform and the mobile network via SMS are used to communicate notices, warnings and alarms.

For the physical design of the stations, 3D printing can be used for sensor covers. In addition, the use of solar panels provides independence from the electricity supply, which should be a requirement as problems usually occur with the electricity supply during disasters.

In conclusion,

- An approach that sees EWS as a social process that covers technical aspects is fundamental to avoid making the common mistake of thinking that a monitoring system is sufficient; it is essential for it to effectively involve vulnerable people and include various technical-scientific and government institutions.

1 Local name for a series of phenomena like mudflows and landslides.

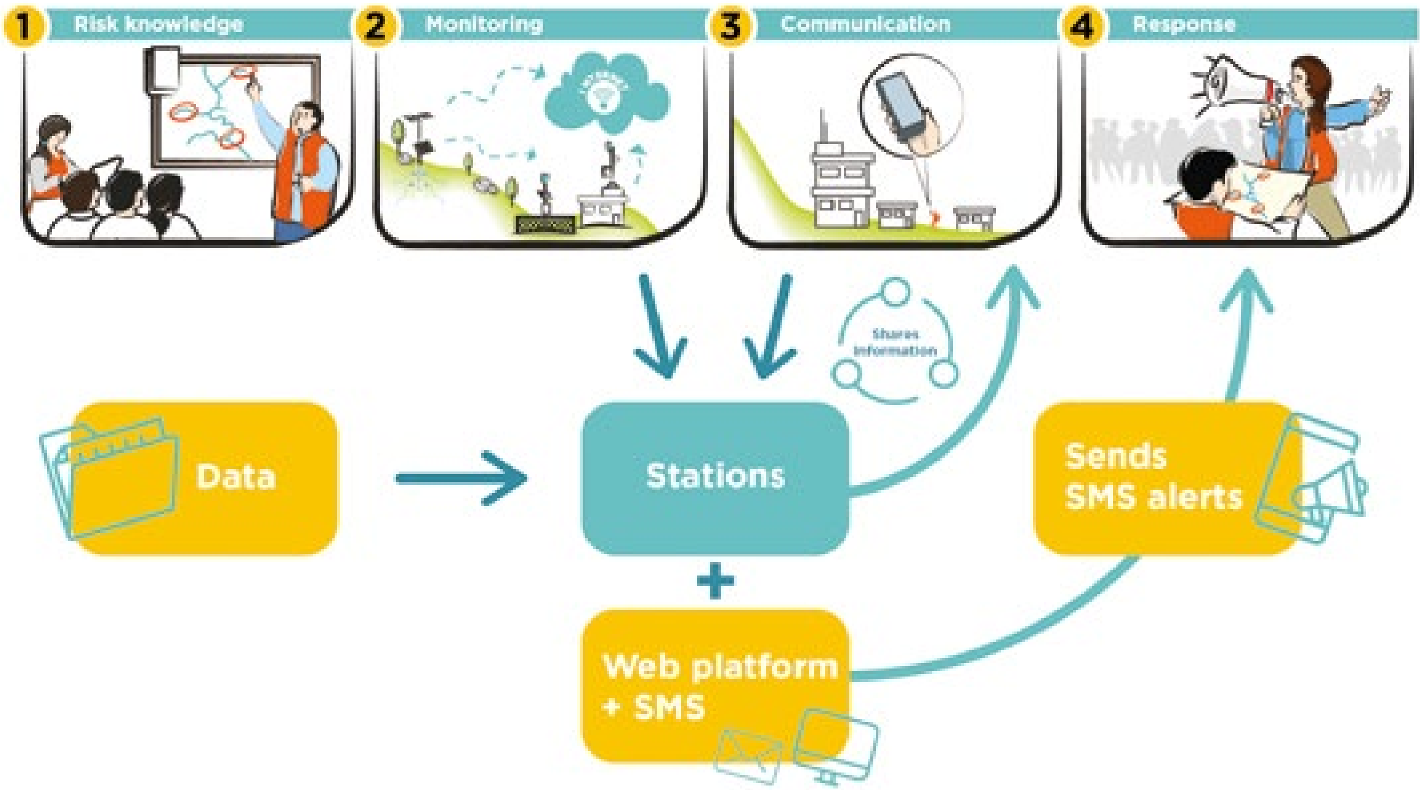

Figure 1. Steps of the Early Warning System.

- Another important approach to consider is working with appropriate technologies, either by developing, adapting or managing them, ensuring that they respond to the needs of the most vulnerable people.

In order to learn about other experiences that use similar technological tools in other areas or topics, it is suggested to review the official Raspberry Pi meteorological station for teaching programming in schools, the UCAR-USAID meteorological station for developing countries (Kucera & Steinson, 2017) tested in places in Africa and Central America, the Environmental Virtual Observatories (EVO) also applied for early warning in the EVO Landslide project led by Imperial College London (Paul et al 2017) and the INAIGEM glacier lake level monitoring equipment (INAIGEM, 2017), among others. These experiences can serve as a reference to be replicated or adapted in other areas.

How it helps to develop resilience : Case-study

Practical Action has developed the *Qawaq* climate information system as part of the EWS for floods and mudslides (*huaicos*) in the Lurigancho-Chosica district since 2016. These are very frequent phenomena in Peru and it is estimated that about 30%[2] of the population is highly susceptible to them. Furthermore, in many cases the mudflows increase the volume of the rivers, coupling the two phenomena. The indirect impacts created, such as roads being cut off, affect the supply of food and the flow of business to big cities. Various measures are required to manage this risk, from mitigation infrastructure to preparedness and response actions like EWS.

After the study of gaps for the implementation of EWS, it was decided to cover areas that were not monitored and variables not previously measured, such as measuring rainfall by each micro-watershed and soil saturation and

2 Source: Risk Scenario during the 2017-2018 rainy season, CENEPRED

taking visual records. Some monitoring stations were set up on the roofs of homes of community volunteers, others in the high areas of hillsides. Given the total coverage of the cellular network and the availability of smart phones, they were the means of communication used.

Among the results obtained during the 2017 rainy season, the most outstanding was the combination of local knowhow and technical-scientific knowledge. Monitoring with a very fine temporal resolution (data per minute instead of per hour) was implemented based on local suggestions, which proved to be adequate for the variables used and current analysis methods. As we had developed it ourselves, its adaptation was simple and with no additional costs, since the only requirement was to change parts of the station codes.

Furthermore, a cooperation agreement was signed with the KOICA[3] Agency, which together with the National Civil Defence Institute installed a network of high-technology stations in nearby micro-watersheds. This agreement enabled us to verify the advantages of monitoring each micro-watershed and the usefulness of our equipment as a complement to high-technology equipment, as they are accurate enough for decision-making.

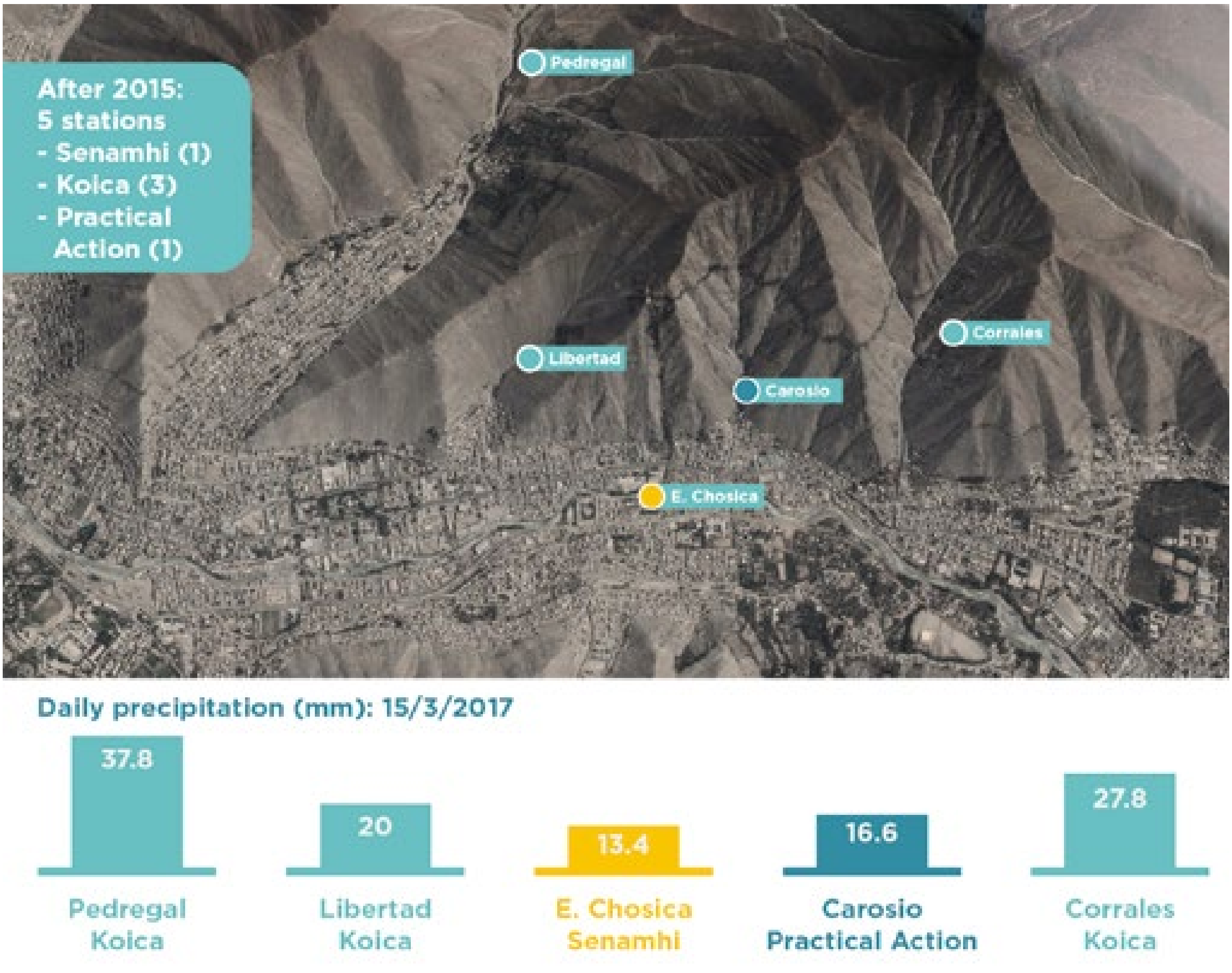

Figure 2. Location of the five stations in Chosica and the difference of their measurements.

3 Within the framework of the project “Implementation of an Early Warning System for Landslides and Mudflows in the Watercourses of La Libertad, Pedregal and Corrales in the Municipality of Lurigancho – Chosica” implemented by the Korean International Cooperation Agency – KOICA.

Photos 3 and 4. Early version of a monitoring station installed in Chosica, Lima - Peru.

Proposals are currently being prepared to extend this experience, with the help of either the government or international cooperation agencies.

Although this technological solution is helpful for the implementation of EWS, it is not self-sufficient. Processes aimed at the response capacity of the community and coordination between official and local entities are needed, among other things. Therefore, part of the process implied the establishment of community brigades who produced low-cost hand-made rain gauges (S/10 or US$3), which contributed to technical monitoring. In addition, a Network of Resilient Leaders of the Rimac watershed was formed, which was linked to the EWS as an additional channel of communication with a wider scope. Social, organisational and technological processes should not be parallel but coordinated. That is the only way EWS can contribute to community resilience.

Cost of the solution based on the case study

ITEMS*	COST IN US DOLLARS
Support structure	100
Raspberry Pi (microcomputer) & items	55
Sensors	15
Filament for 3D printing	60
Photovoltaic System	80
Data transmission	20/month
Approx. total / site	**330**

* The format of the costs table was adapted from Kucera & Steinson (2017)

References / citations

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Practical Action is a member of the Zurich Flood Resilience Programme, a multi-sectoral alliance focusing on helping communities in developed and developing countries strengthen their resilience to flood risk.
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