The Costa Rica Early Warning System for the Hydrometeorological Hazards Project

A Story from Costa Rica

Geographical, Historical, Environmental Context of the pilot site of the Project

Sarapiqui is a rural Municipality belonging to Heredia Province in Costa Rica, and it is comprised by five districts (Box 1). The head town is Puerto Viejo. The Sarapiqui River is one of the most important of the basin which irrigates this region. The earthquake of 6.2 degrees magnitude on January 8, 2009 at the Cinchona area had an important impact on the landscape and hydrological variability in the Sarapiqui Basin changing the risk scenario at the basin. The drainage patterns suffered modifications and new risk areas for flash floods and mudslides has been created.

The tons of material from landslides that fell into the river channel caused a huge avalanche that moved at high speed down the gorge of the river, endangering riverine communities and destroying much of the vegetation along the riverbanks and raised the height of riverbed due to the sediment accumulated. Landslides that may be triggered by heavy rainfall or earthquakes remain a threat in the mountainous areas of the upper basin, adding new elements and complexity to the prevalent risk situation.

Box 1 : Relevant Information on Sarapiqui Municipality

Location and size: Sarapiqui is located at the North Caribbean region of Costa Rica (its Coordinates are 10°29’23’’ North latitude and 83°56’15” West longitude); and with an area of 2,140.54 km² is one of the largest Municipalities of the country and it has boundaries to the North with Nicaragua

Population: Total 57.147, which 28.090 are women and 29.057 men. Density is 27 persons/km² distributed in 5 districts: Puerto Viejo (Head town), La Virgen, Horquetas, Llanuras del Gaspar, Cureña

Production: Agriculture and livestock farming have been the main traditional activities, and nature-oriented tourism has emerged recently, so increasing related activities of commerce and services

Social situation: Very high rate of temporary and informal employment. Percentage of poor families is 35%

Geography and weather: This region is predominantly hot and one of the most humid of the country, with average temperatures ranging between 26 and 28° C. It is continuously influenced by trade winds and seasonally by tropical depressions and cold fronts that intensify between November and February. The elevation of the main towns ranges around 37 to 187 masl (meters over the sea level)

Environmental characteristics: The Sarapiqui territory is surrounded by dense rain forests, it is the home for wildlife, forest preserves and national parks, it is very important for water resources and biodiversity protection

Hydrologic characteristics: This is one of the 34 main watersheds of Costa Rica; the Sarapiqui river drains into the San Juan River and is the main water body that bath this region together with a group of rivers and streams fed by year-long rainfalls with periods of heavy rains between November and January

Hazards: Due to the combination of hydrographic, topographic characteristics, weather conditions and seismicity, the most important hazards for Sarapiqui region are flooding and mudslides. Landslides falling into the river adds new elements and complexity to the prevalent risk situation

About the "Costa Rica Early Warning System for the Hydrometeorological Hazards Project"

To address these new challenges, the World Meteorological Organization through its Disaster Risk Reduction Programme, Regional Office IV (North and Central America) in Costa Rica and the Hydrology and Water Resource Programme, collaborated with the World Bank Global Facility for Disaster Risk Reduction (GFDRR), the National Meteorological Institute (IMN), the National Commission of Risk Prevention and Emergency Response (CNE) and the Costarican Institute of Electricity (ICE) through the implementation of the "Costa Rica Early Warning System (EWS) for Hydrometeorological Hazards Project". The project was funded by the World Bank and the GFDRR, and it started in early 2012 and it was completed in June 2013.

The purpose of the project was to develop an effective framework for an operational early warning system (Box 2) at the Pilot Site of the Sarapiqui river basin, strengthening coordination and cooperation among IMN, ICE, and CNE in collaboration with other national government and non-governmental agencies at the local level to strengthen the emergency preparedness and response, including community participation in the Project implementation and development.

The scientific and technical information developed through this project provides the elements for risk based warnings/advisory, which are communicated to the local population in a language they understand. Providing clear risk based information (e.g. hazard characteristics and potential consequences of the hazard) allows local organizations and communities in the threatened area to implement pre-planned measures (also developed through this project) to protect their lives and livelihoods.

Box 2: Early Warning System

An early warning system has four components, which include:

(i) Detection, monitoring and forecasting hazards,

(ii) Analyses of risks involved,

(iii) Dissemination of timely warnings - which should carry the authority of government,

(iv) Activation of emergency plans to prepare and respond to an imminent or forecasted hazard.

These four components need to be coordinated across many agencies at national to local levels for the system to work. Failure in one component or lack of coordination across them could lead to the failure of the whole system. The emission of warnings is a national responsibility; thus, roles and responsibilities of various public and private sector stakeholders for implementation of EWS should be clarified and reflected in the national to local regulatory frameworks, planning, budgetary, coordination, and operational mechanisms

"With this project, we intend to transfer all this accumulation of highly technical information generated to the communities in simple language, so they can make decisions and take actions for protection, according to the received information "
Oscar Arango, WMO

Communities in the Sarapiqui region

More than 30,000 people live in riverine villages and flood areas along the rivers, and they are exposed to the overflowing of the Sarapiqui, Puerto Viejo, Sucio rivers, among others. This situation of recurrent floods is exacerbated by the growing population at the flood-prone areas, which increases the overall vulnerability of the community in the affected areas.

Community Emergency Committees (CECs) were created in several villages of the Sarapiqui region following the 2009 earthquake at Cinchona, which provided the basis for the organization of the local response component of this Project. The CECs are established through the Costa Rican National Law of Emergencies and Risk Prevention (Law 8488), under the responsibility of the National Commission for Risk Prevention and Emergency Response (CNE). CECs are composed mainly of representatives of the civil society and one of its priorities is the promotion of community organization for disaster risk reduction and implementation of emergency response interventions in their community.

Operations coordination center at the Community Emergency Committee in Naranjales during the drill exercise

Another relevant coordination body is the Municipality Emergency Committee (MEC), in charge of promoting and coordinating all risk management and emergency response issues at the local level (Figure 1). The MEC is an inter-institutional body composed mainly by governmental organizations and it has the task of gathering all strategic sectors to participate in these issues, as well as organizing and supporting the CECs. The head of the MEC is the City Major.

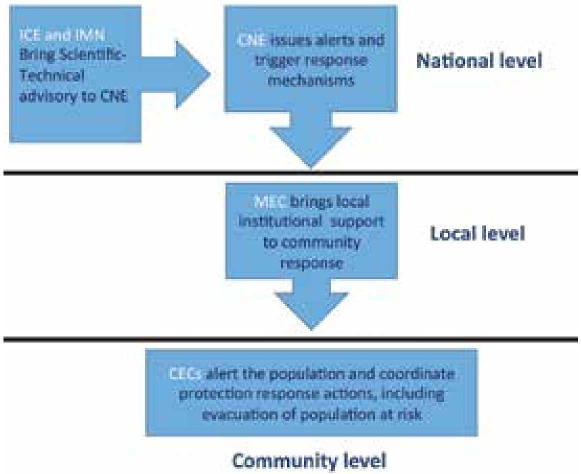

Figure 1: Disaster Risk Management institutional roles and responsibilities in the EWS context

Project Outcomes
Technical outcomes

In order to develop this EWS, it was necessary to calibrate a hydrological model using the flood hydrographs registered at ICE gagging station that corresponded to the lumped hydrological response of the Sarapiqui and Puerto Viejo river basins, along with the precipitation records of 20 rain gauges.

The space and time distribution of rain was determined based on the continuous records of 10 rain gauges. Some of the records of these gauges had to be read using digital pictures and color contrast on the computer, because ink on the paper is fading away and it was very difficult to read the information directly on the paper.

On the Puerto Viejo and Sucio river basin there are no rain gauges at all. Therefore, the volume of precipitation, and the space and time distribution of the rain for these rivers basins had to be estimated based on the Sarapiqui River Basin data.

These flood hydrographs, the precipitation volume and the space and time distribution of the rain were useful for calibrating the combined hydrological model for the Sarapiqui and Puerto Viejo drainage areas.

Once having calibrated the hydrological model, individual hydrological responses of the Sarapiqui and Puerto Viejo rivers were determined. Because of the lack of a gagging station at the Sucio River and at the main sub-basins of the Sarapiqui River, the flood hydrographs for these basins were synthetically determined, using the information derived from the Sarapiqui and Puerto Viejo.

With the calibrated hydrological model, flood hydrographs with a return period of 5 years, 10 years, 25 years, 50 years and 100 years were estimated. Flood hydrographs were routed through flood plains and flood prone areas were determined for each return period.

Flow rate on the main river channel and on the flood plains is also a very important parameter for EWS. Therefore, space distribution of the flow rate were estimated and mapped over the flood prone areas (Figure 2 and 3).

To improve the hydrological model and the confidence level of estimated flood hydrographs and flood

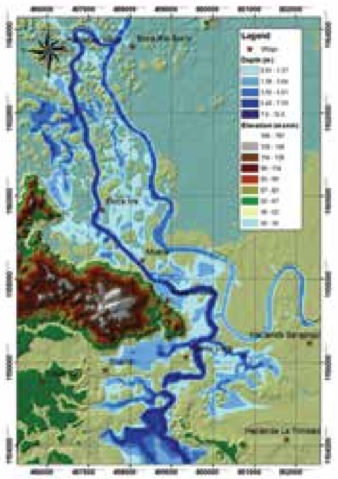

Figure 2. Flood prone area for the flood hydrograph produced by the 50-year return period storm

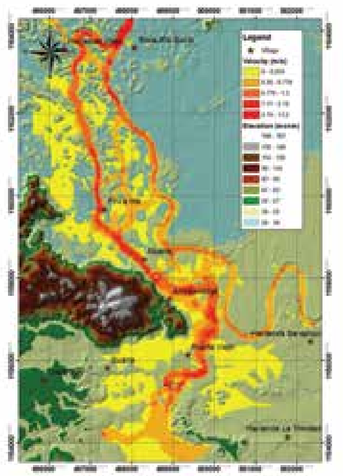

Figure 3. Flow rate distribution over the flood prone area, for the flood hydrograph produced by the 50-year return period storm.

prone areas, two Automatic Weather Stations (AWS) were installed as part of this project at the Puerto Viejo River Basin. The information recorded by these meteorological stations will validate the space and time distribution of the rain and it will allow to improve rain forecast for the EWS.

"The project has allowed an improvement on the numerical model that we use as forecasting tool for prediction and a clearer identification of thresholds, so we can generate warnings for 48-24 hours in advance".
Juan Carlos Fallas,
IMN Director

Community participation, organization and training

Throughout the Project implementation, around 200 representatives belonging to CECs of 20 communities from the mid and lower Sarapiqui basin actively participated in the training and organizational strengthening activities. Through a series of workshops and fieldwork, members of these committees were trained on:

- ✓ identifying and mapping areas at flood risk in their communities
- ✓ organization of response activities
- ✓ use of radio communication devices
- ✓ warning and evacuation procedures
- ✓ emergency shelter management
- ✓ water and sanitation
- ✓ protection of animals in emergencies
- ✓ community census and inventory of community resources

CNE and IMN worked together with local authorities and communities to develop standardized operations procedures (SOPs) to be implemented when a hydrometeorological hazard is deemed as a threat by IMN for the country and for the Sarapiqui region in particular. The purpose of SOPs is to establish procedures for hydrometeorological threat monitoring, alert declaration and activation of response mechanisms (Box 3.)

SOPs establish clear actions for all levels (national, municipal, community) and all times (monitoring, warning, alert, response). These actions must be incorporated and synchronized by the institutions and committees in their own emergency plan.

Box 3. The basic premises for the SOPs

- The decision to evacuate is supported by reasonable certainty based on the thresholds provided through the EWS
- The spirit of the EWS is anticipation: local response structures receive sufficient and timely information to take the necessary protective measures. Population is alerted and instructed in advance enough so they can protect themselves and their goods before the overflow of rivers, so reducing the need of rescue operations

There has been an outstanding and active participation of women in the project. This fact is not surprising, taking into account the leadership of women and commitment of women in the daily struggles to improve their communities.

Unprecedented Coordination and Cooperation

All activities of the Project were carried out through an unprecedented close coordination and cooperation among the different stakeholders involved, each one leading its area of expertise and enthusiastically supporting the development of the other institutions' activities. The IMN had the general coordination and it brought specialized support for the development of the Technical Scientific component of the Project; the CNE coordinated all the activities related to risk and disaster management on the Project, and the ICE supported the Technical-Scientific component of the Project by providing substantial information obtained from their extensive monitoring networks in the basins. Their abundant contribution on human and material resources has allowed to have an amplification of the results obtained by the Project.

The communities that have participated enthusiastically in all activities of the project are committed to continue to fortify the organization by including other community groups in the process.

"Now community people are more aware to follow the instructions given by the emergency committee and when alerts are communicated, they move to shelters". Marcia Gonzalez, Naranjales CEC member

Simulation exercise

In order to determine the pertinence and the level of local ownership of the EWS, a drill and an associated simulation exercise were conducted, involving all organizations related to its use and application. In the drill that took place simultaneously at Los Lirios, Naranjales, Caño San José and the Municipality Emergency Committee, the participating communities and institutions had to face situations that simulated the arrival of a dangerous hydrometeorological hazard that would affect the region. The drill tested the EWS from the institutional level up to the community level, such as the application of SOPs, warning messages, evacuation procedures, communication procedures, understanding of the community of the warning messages and procedures, etc., as well as the general behavior and performance of the organizations facing such extreme situation. More than 800 hundred persons took part of this exercise, corresponding to 27% of the population of the three participating communities.

The drill and simulation exercise were evaluated by a team comprised by members of MECs from other Municipalities of the Province. They assessed the actions and decision making process (e.g. information tracking, monitoring activation, activation of CECs, communication of alarms and alerts, evacuation, shelter activation, situation reports, supplies management, etc.), according to the established drill scenarios, and they briefed with their observations the different participating organizations.

Correspondingly, the participants did their own evaluation on their performance, outcomes and gaps that needed to be addressed, as well as the related corrective actions to be taken in order to strengthen the EWS.

This type of exercises and their corresponding evaluation have proven to be an ideal feedback mechanism to ensure ongoing improvement of EWS.

Lessons learned and way forward

Lessons learned

- ✓ CECs still require strengthening their organization and increasing their skills for a larger release of information, and encourage greater and more active participation from the communities.
- ✓ Progress made with this Project has been substantial; the efforts and contributions made by the participating institutions have been enormous and they have undoubtedly contributed to the success obtained. However, the most encouraging is the willingness and enthusiasm of these organizations to keep supporting the growth of the results achieved, to ensure its long-term relevance and sustainability.
- ✓ The graphic expression and explanation of SOPs and other related procedure SOPs for community level can still be simplified in order to make their understanding easier and their application easy,
- ✓ CECs members need to be familiar with SOPs, so it is very important to continue working on their organization and training. A yearly exercise at the beginning of the rainy season should be a good refreshing tool to create awareness and preparedness "tradition" in the community.
- ✓ It is necessary to continuously review and update the hydrological response of the basin, to keep the capacity building process of the population to know what to do once the forecast is received and to improve the hydrometeorological network to build up confidence of the population on the warning system.
- ✓ According to national governmental officials, this Project reveals the need to adjust and strengthen legal mechanisms to enhance the implementation of warning systems of this type, and get more effective the crucial actions, such as issuing of alert, evacuation orders, emergency sheltering, etc.

The organization and operation of the EWS requires the joint work of institutions and communities

Scaling up to other regions in Costa Rica

This Project provides a model that could be utilized in other regions in Costa Rica because it addresses all four basic components of a EWS (Box 2.) and it strategy include:

- ✓Technical and organizational engagement and participation of national institutions: technical and scientific related institutions must provide human and technical resources for the development of the EWS, and compromise to support and follow up of results
- ✓Municipality authorities are actively engaged and they are supporting community efforts: Municipality must be an active partner and provide political and institutional support to the implementation and results of the Project
- ✓Institutions at local level supporting the Project in the areas related to their specialties
- ✓Active participation of communities: Community organizations involved in the whole process, including not only the CECs but other organizations functioning in the community.

"The project has the necessary ingredients to be replicated in other basins of the country, since it has a good balance of scientific technical aspects to be provided to a community which has managed to build their capacity to understand and respond to a recurrent natural phenomenon".
Rafael Oreamuno, hydrologist.

EWS procedures should be known by all organizations and institutions related to its implementation, and disseminated to communities to ensure a correct and timely response

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