Climate Resilience Alliance

SOLUTIONS BRIEF

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Practical Action

River monitoring for early warning systems using lidar sensors

Summary

Practical Action has been working with Imperial College London (ICL) to test light detection and ranging (lidar) sensors in Nepal, Peru, and Bolivia. These sensors can be used to improve river level monitoring and therefore provide more localized, timely, and accurate forecast information for flood early warnings. Improved monitoring helps riverine communities take action to protect lives, assets, and livelihoods. By taking these protective actions, communities can strengthen their human, financial, and social capitals, which helps to build their resilience.

Our approach

Communities in Bolivia, Nepal, and Peru face similar early warning challenges due to their complex, mountainous geographies and the need for river monitoring in remote areas. Using the Flood Resilience Measurement for Communities (FRMC), Practical Action identified a need to improve river monitoring and provide more localized information.

To address this challenge, Practical Action worked with ICL to run pilot studies to test the potential of lidar sensor technology, which is open source, allowing for replication and scale in other contexts.

Facts and figures

Cost of lidar sensor river monitoring station:
Context specific, but generally
US$300–500
excluding installation

Ongoing costs/maintenance:
Context dependent, but around
US$5–10 per month
for cellular communication and data-hosting services

Time to implement:
One day learning, one to five day installation, one rainy season for calibration

Easy to replicate?
Somewhat

Practical ACTION

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Practical Action staff programming the hydrological monitoring station with lidar technology in the field in the Vilcanota basin, Cusco, Peru, 2022. Giorgio Madueño (Practical Action)

Hydrological monitoring station using lidar technology with metallic protection cover in the Vilcanota basin, Cusco, Peru, 2022. Giorgio Madueño (Practical Action)

What was the problem?

Across many contexts, the timeliness and quality of warnings are often insufficient for effective decision-making and early action.

Early warnings that lead to anticipatory action rely on each component of an early warning system (EWS) working effectively. Data from the FRMC indicated that there were several weaknesses that reduce the effectiveness of river monitoring. These include the high cost of traditional river gauging stations (e.g. US$10,000), which contributes to low or partial coverage, particularly in complex and diverse terrain, resulting in a lack of locally specific warning information, especially along medium and smaller-sized rivers, and barriers to the transfer of real-time data, including distance, geography, and mobile/internet connectivity.

What was the solution?

Insights from the FRMC process suggested that there was a gap in monitoring and warning in many contexts, leading to EWSs that did not provide localized warning information for communities at risk. Working with communities, Practical Action identified that low-cost sensors, such as lidar sensors, could be an effective solution. They are effective for the following reasons:

- Measurement capability: they are highly accurate at recording river levels and flood-water levels and can detect water levels from further away compared to the ultrasound method of monitoring. This allows for continuous monitoring of varying river levels throughout the year.
- Easy installation: they can be installed on existing structures, such as bridges, with little effort and cost. They also measure water level at an angle, so they can be installed on the riverbank looking sideways, providing flexibility in site selection, convenient access for maintenance, and reduced risks of being damaged during floods.
- Low cost: they cost less than US$500, excluding installation costs, compared to US$10,000 for high-tech monitors. This lower cost means stakeholders can afford to increase the spatial coverage of monitoring in their areas. They are also very power efficient, which is an asset in remote regions and further reduces the cost.
- Open source: the open-source nature of the technology supports local maintenance, as components can be constructed and assembled locally, supporting local capacity, improvement, and innovation, and enhancing the robustness and cost-effectiveness of monitoring equipment.
- Scalability: the software components (data storage, telemetry, visualization) can be scaled up conveniently and cost-effectively through cloud services.

Climate Resilience Measurement for Communities (CRMC)

The Climate Resilience Measurement for Communities (CRMC) is a data-driven process, complemented by a web-based tool and mobile app, which helps communities to evaluate and measure how resilient they are to climate hazards. Using the results, they can identify and implement resilience-building interventions and run additional measurements to track improvements.

Find out more: ZCRAlliance.org/crmc

How does it increase resilience?

The pilot studies demonstrate that there is promising potential for lidar sensors in locations with low data spatial resolution, in mountainous or remote areas, and in areas where people are most in need of locally relevant and timely flood early warning information. More timely and improved warning information can inform planning and warning information can inform planning and preparedness, which can help people take early action to protect their lives and assets.

The low cost means the sensors can be installed in multiple locations and in more remote locations, expanding the monitoring density and coverage, which can improve understanding of flood risks, especially on smaller and medium-sized rivers. Lower costs also mean that lower priority, more marginalized locations might be able to install and maintain sensors.

Because they are open source and open access, components can be constructed locally, which contributes to long-term maintenance and sustainability and encourages community engagement and local ownership.

Early Warning Systems (EWS)

EWS are one of the best-proven and effective measures for saving lives and minimising losses and harm caused by disasters. They help those at risk of floods, heatwaves, wildfires and other climate hazards to take risk-informed, timely, meaningful and impactful early action to keep themselves and their assets safe. The Alliance works across all eight components of an EWS so that they deliver essential services for the most vulnerable women, men, and children, supporting communities to be resilient to climate hazards, enabling them to thrive.

Success story

Practical Action Peru have demonstrated the effectiveness and applicability of lidar sensors in monitoring river levels through pilot studies and are working with the National Service of Meteorology and Hydrology of Peru (SENAMHI) to improve the coverage of monitoring stations in the Vilcanota river basin in the Cusco region of Peru for improved EWSs.

"… this has allowed us for the first time to have several points in the Vilcanota river basin that will help us understand what floods are like.

Waldo Lavado, Subdirector of Hydrological Studies and Research, SENAMHI.

Hydrological monitoring station with lidar technology in the Vilcanota watershed with support structure, Cusco, Peru, 2022. Giorgio Madueño (Practical Action)

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Expert view

"Lidar has proven to be a cost-effective, robust, and reliable technology to build flood early warning systems for rapid and anticipatory action. Its open design makes it affordable and stimulates local technological innovation."

Professor Wouter Buytaert, ICL.

Hydrological monitoring station with lidar technology in the Vilcanota watershed with support structure next to a limnimetric ruler, Cusco, Peru, 2022. Giorgio Madueño (Practical Action)

Lessons learnt

- **The open-source nature of the hardware coupled with a community-led approach enables improved localization of information as well as local capacity development.**
- **Lidar sensors are not a panacea. It is important to build redundancy in the EWS by having multiple sources of data and systems to support continued operation.**
- **Connecting with national stakeholders can provide a route to scale and sustainability once proof of concept is achieved through the pilot of flooding.**

Get in touch

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Further Reading

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The Zurich Climate Resilience Alliance is a multi-sectoral partnership, powered by the Z Zurich Foundation, focused on enhancing resilience to climate hazards in both rural and urban communities. By implementing solutions, promoting good practice, influencing policy and facilitating systemic change, we aim to ensure that all communities facing climate hazards are able to thrive. **Find out more at ZCRAlliance.org**

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