TAAL VOLCANO ERUPTION : THE IMPORTANCE OF SCIENCE AND SCIENCE COMMUNICATION

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Summary

On January 12, 2020, Taal Volcano in Batangas, Philippines, explosively erupted after 43 years of dormancy. For about 2 weeks after the eruption began, Alert Level 4 remained in place and the public was urged to abide by the 14-kilometer radius danger zone of the volcano. This eruption was a test to the country's disaster preparedness.

An analysis of publicly available datasets shows remarkable increase in daily seismicity, profound number of felt earthquakes, rapid inflation, and lower than normal water level measurements at least 2 months prior to the 12 January 2020 eruption. However, Alert Level 2 was raised only on the day of Taal's eruption, which was further raised to Alert Level 3 by 4:00 pm and then to Alert Level 4 by 7:30 pm of the same day. In the succeeding days, people were forced to evacuate due to increasing unrest as recorded by monitoring instruments, and yet the predicted more violent eruption never happened.

The harsh impacts of natural hazards can be prevented and mitigated through scientific data and information understandable by people and grounded in their realities. Thus, participatory workshops in communities to discuss actions in times of crisis are recommended. Through these activities, opportunities are provided for stakeholders to express their opinions and have ownership of actions that will be effective during crisis situations.

Moreover, the need for a "people-centered" early warning system is emphasized, where "agreed-upon" response actions are designed on the ground by both the experts and the community. This early warning system, created through a participatory process, includes four key elements: (1) disaster risk knowledge based on the systematic collection of data and participatory disaster risk assessments; (2) detection, monitoring, analysis, and forecasting of the hazards and possible consequences; (3) dissemination and communication of authoritative, timely, accurate, and actionable warnings and associated information on likelihood and impact; and (4) preparedness at all levels to respond to the warnings received.

Science is assumed trustworthy in our country's disaster risk reduction efforts. But if a person or persons in a community do not believe that it is trustworthy, then science communication breaks down. This gap must be bridged for our disaster risk reduction system to work and can be addressed with a "people-centered" early warning system, created through a participatory process with science that is transparent and empowering.

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On January 12, 2020, Taal Volcano explosively erupted after 43 years of dormancy. The eruption started at around 1 pm and within hours escalated to a magmatic eruption characterized by lava fountaining (PHIVOLCS, 2020). For about 2 weeks since the eruption began, Alert Level 4 remained in place (Table 1). The public was urged to "not risk their safety and their lives" and abide by the 14-kilometer radius danger zone of Taal Volcano.

After several days under Alert Level 4 and with visible warning activity, some people questioned the reliability of the prediction of PHIVOLCS. Talisay Vice Mayor Charlie Natanauan claimed that the warning of PHIVOLCS of an imminent hazardous eruption was based on "opinions" and only sensationalized the situation of the volcano. He added, no one, even scientists, can predict when a volcano will erupt (CNN, 2020). In response, PHIVOLCS defended the advisories they send out to the public and remained firm in their science.

Table 1. Alert levels for Taal Volcano. Abridged version (Phivolcs,2020)

ALERT LEVEL	CRITERIA	INTERPRETATION
0	Background quite; low level seismicity	No eruption in foreseeable future
1	Low level seismicity, fumarolic, other activity	Magmatic, tectonic, or hydrothermal disturbance; no eruption imminent
2	Low to moderate level of seismic activity; persistence of local but unfelt earthquakes. Ground deformation measurements above baseline levels	A. Probable magmatic intrusion. Could eventually lead to an eruption B. If trend shows further decline, volcano may soon go to Level 1
3	Relatively high unrest manifested by seismic swarms including increasing occurrence of low frequency earthquakes and/or harmonic tremor (some felt)	A. If trend is one of increasing unrest, hazardous eruption is possible within days or weeks B. If trend is one of increasing unrest, volcano may soon go to Level 2
4	Intense unrest, continuing seismic swarms	Hazardous eruption is possible within days
5	Base surges accompanied by eruption columns or lava fountaining or lava flows	Hazardous eruption in progress. Extreme hazards to communities west of the volcano and ashfall on downwind sectors

A review of the events before and after the 2020 eruption of Taal Volcano shows opportunities to improve science communication through warnings that are accurate, reliable, understandable, and timely. Effective science communication, before, during, or after a crisis situation, can elicit the desired response from affected communities and confidence from policymakers and the public at large.

Events Before and During the Eruption

Because of increasing unrest of the volcano, PHIVOLCS was prompted to raise the alert level of the Taal Volcano on March 28, 2019 to Level 1 out of a total of six alert levels (Table 1). Alert Level 1 remained in place until immediately before the eruption on January 12, 2020 (PHIVOLCS, 2020).

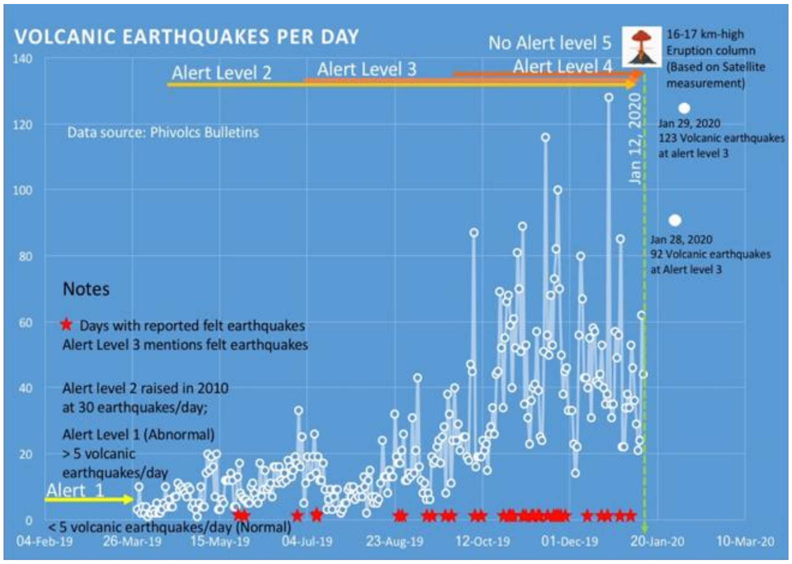

Figure 1. Number of daily volcanic earthquakes starting March 2019 showing an increasing trend in the runup to the 12 January 2020 eruption. Felt earthquakes are also plotted in the graph as red stars.

Analysis of publicly available datasets (PHIVOLCS, 2019-2020; WOVO, 2020) reveals the remarkable increase in daily seismicity, profound number of felt earthquakes (Figure 1), rapid inflation (Figure 2), and lower than normal water level measurements (Figure 3) prior to the January 2020 eruption. These records, which contain documentation of days that have more than 100 earthquakes, may have been used to further increase the alert to at least Level 2 as early as November 2019. For comparison, Alert Level 2 was already raised during the 2010 Taal seismovolcanic crisis with only 30 earthquakes per day (Zlotnicki et al, 2018).

Other publicly available datasets that did not clearly manifest abnormal measurements were the main crater lake water temperature and pH levels. Alert Level 2 was only raised on the day of Taal's eruption that generated a 10–15 km-high eruption column. Other estimates of the eruption height are in the range of 16–17 kilometers (PTCC, 2020) and even up to 21 kilometers (Bachmeier, 2020). On the same day, it was raised further to Alert Level 3 by 4:00 pm and then to Alert Level 4 by 7:30 pm (PHIVOLCS, 2020). The tall eruption column caused ash to fall as far as Metro Manila and even further north. Alert Level 5, which means a hazardous eruption is in progress (see Table 1), was not raised despite the obvious perilous eruption that was already taking place including the formation of phreatomagmatic surge flows (base surges).

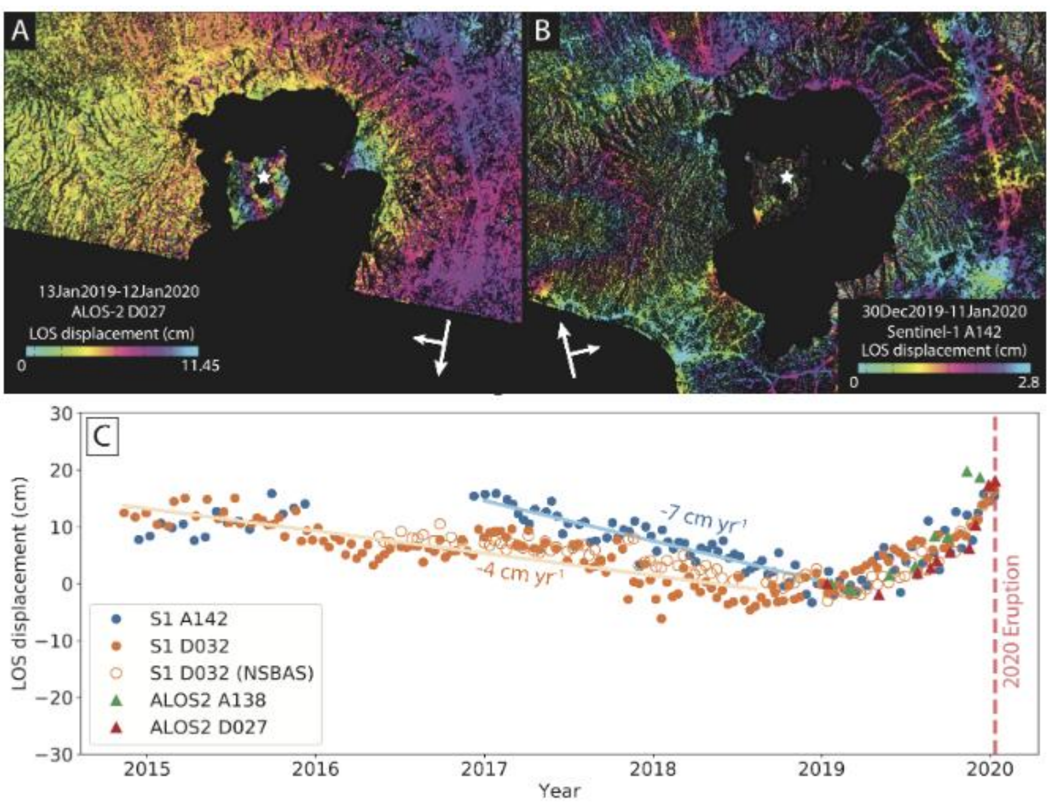

Figure 2. InSAR analysis showing Line of Sight (LOS) displacement indicative of rapid inflation of Taal Volcano starting 2019 (Bato et al, 2020).

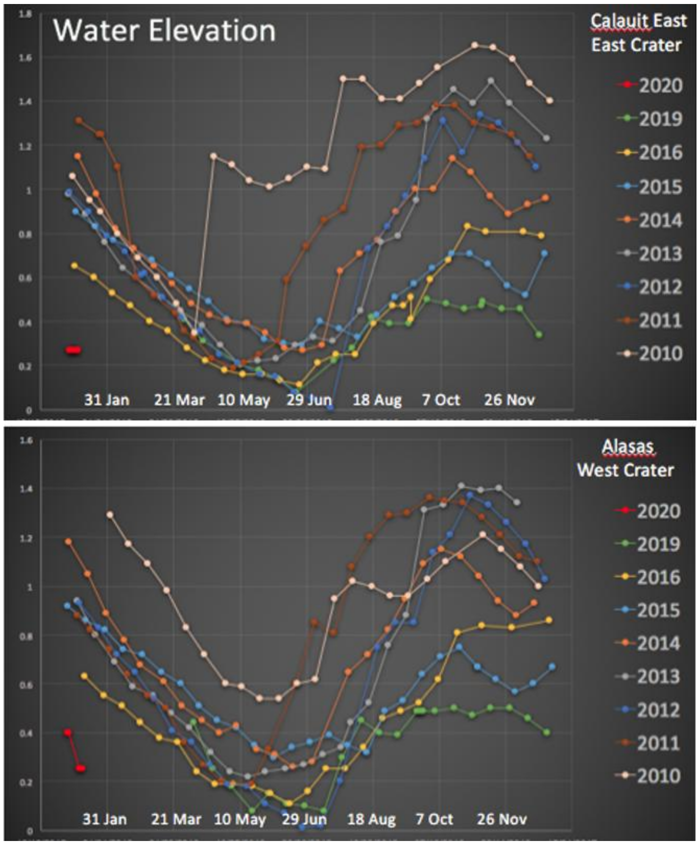

Figure 3. Water level measurements in meters for the year 2010-2016 and 2019-11 January 2020. Note the very low crater lake water level measurements from November-December 2019 and January 1-11, 2020 as compared to previous years. Data source: Phivolcs 2019-2020 bulletins and WOVO, 2020 (https://wovodat.phivolcs.dost.gov.ph/).

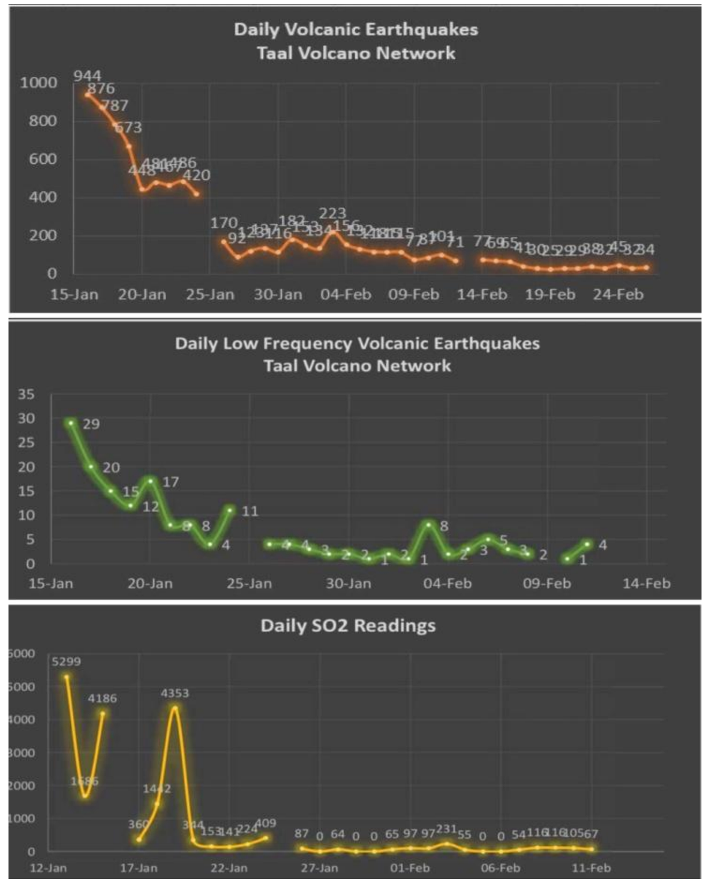

Figure 4. Records of daily volcanic earthquakes, low frequency volcanic earthquakes and daily SO2 readings (tonnes/day) after 12 January 2020. Data source: PHIVOLCS daily bulletins. Graphs plotted by Rich Ybanez.

Events After the Eruption

In the succeeding days, monitored parameters such as volcanic earthquakes, low frequency earthquakes, and sulfur dioxide (SO2) for Taal's activity were extremely high and dangerous (Figure 4). A 14 km radius exclusion zone was put in place based on the hazard maps of PHIVOLCS for ash fall, bases surges, and volcanic tsunamis. Even the highland areas of Tagaytay City, Cavite, and Cuenca, Batangas were included in the instruction of DILG to be evacuated (Galvez, 2020).

During the period of intense unrest from January 13 to 15, people were forced to evacuate as evidence for the presence of magmatic activity represented clear and present danger. However, the feared cataclysmic eruption never happened. On January 26, 2020, as signs of unrest were waning (Figure 4), the warning was gradually lowered to Alert Level 1 and has remained as such to date.

The 2020 Taal Volcano eruption resulted in one reported dead and one missing (Cinco, 2020). It was unlike the previous eruptions of Taal Volcano, such as those in the 1911 and 1965 eruptions, where there were many fatalities.

The 12 January 2020 Taal volcano eruption is considered a test to the Philippines' disaster preparedness (Minter, 2020). Immediate responses from both national and local governments were recorded. Evacuation of at-risk communities took place in 16 municipalities of Batangas and two municipalities in Cavite provinces on the advice of DOST- PHIVOLCS (IFRC, 2020). About 5,000 families were immediately relocated to evacuation sites.

The DILG ordered local government units in Batangas to take appropriate measures and activate operations centers in response to Taal

Volcano's eruption. On the other hand, the National PNP and the AFP ordered their various disaster response units in coordination with local DRRMCs to assist local government units affected by the volcanic eruption (Caliwan, 2020). Certainly, the response capability of both national and local governments as well as volunteers to help cope with disasters was demonstrated during this calamitous event.

Conclusions and Recommendations

The awareness and quick reaction of the people to flee the island hours before the explosive activity is the main reason that prevented massive loss of human lives. Unfortunately, the lead time in the warning was insufficient to mitigate the loss of horses and livestock. During the lockdown period, pets and animals were also left behind unfed. These highlight that timely and accurate warnings are important not only in saving human lives but also in mitigating loss of property and livelihood.

We can prevent and mitigate the harsh impacts of natural hazards through scientific information, but it needs to be understood first by people to transform it into knowledge that can save lives. Such transformation requires that science be grounded into people's realities. Participatory workshops in communities where people and scientists discuss actions in times of crisis in advance are imperative. By getting community members and scientists to work together on a plan, opportunities are provided for stakeholders to express their opinions for science to become complementary to their beliefs, rather than a command. When agreed upon, there is an ownership of actions by the community and these become more effective during crisis situations. Ownership of actions, however, necessitate ownership of scientific data that is an important basis for timely decisions by everyone.

Physical parameters of Taal Volcano, which include the number of earthquakes, water level, gas discharge, and inflation of volcano slopes are all measurable quantities that can be matched with corresponding thresholds based on the volcano's past behavior as observed by scientists and recalibrated as needed. They may also be correlated with the interpretation by locals of the behavior of the volcano.

These parameters can be viewed in near real-time using current technologies such as mobile apps and websites and may serve as basis for raising or lowering alerts. From these measured parameters and with identified thresholds, corresponding "agreed-upon" response actions on the ground can be designed. Collective action becomes swift and deliberate when data for agreed parameter thresholds for raising or lowering alert levels are readily accessible.

Moreover, the necessary transparency and objectivity of science provides affected communities with the confidence to trust their response actions. Unfortunately, this type of system was still non-existent during the 2020 Taal disaster. Advisories of the mandated national agencies could have been improved in terms of timeliness and, in hindsight, could have benefited greatly from applicable scientific interpretation, both of which are crucial during emergency and disaster situations.

An effective "end-to-end" and "people-centered" early warning system is comprised of an integrated system, which includes four interrelated key elements: (1) disaster risk knowledge based on the systematic collection of data and participatory disaster risk assessments; (2) detection, monitoring, analysis, and forecasting of the hazards and possible consequences; (3) dissemination and communication, by an official source, of authoritative, timely, accurate, and actionable warnings and associated information on likelihood and impact; and (4) preparedness at all levels to respond to the warnings received. These components need to be coordinated within and across sectors and multiple levels for the system to work effectively; and it is necessary to include a feedback mechanism for continuous improvement. Failure in one component or a lack of coordination across them could lead to the failure of the whole system (Basher, 2006; de León, 2012).

"We must trust in science!" Implicit in this statement is that it is assumed trustworthy. But if a person or persons in a community lose confidence in the science for whatever reason, then everything breaks down. This gap must be bridged for our disaster risk reduction system to work. It is a matter of grave concern and is difficult to execute, but is possible with a "people-centered" early warning system, created through a participatory process with science that is transparent and empowering.

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