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EDITED BY
Karen Fontijn,
Université libre de Bruxelles, Belgium

REVIEWED BY
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Nanyang Technological University, Singapore
James Kauahikaua,
United States Geological Survey, United States

*CORRESPONDENCE
Ma. Mylene Martinez-Villegas,
mylene.villegas@phivolcs.dost.gov.ph

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Perspectives on the 12 January 2020 Taal Volcano eruption: An analysis of residents' narrative accounts

Ma. Mylene Martinez-Villegas[1]*, Paolo D. Reniva[2], Lucille Rose D. Sanico[1], Allan R. Loza[2], Ricardo G. Seda[2], Dynie F. Doloiras[1] and Abigail C. Pidlaoan[1]

[1]Philippine Institute of Volcanology and Seismology-Department of Science and Technology (DOST-PHIVOLCS), Quezon City, Philippines, [2]Philippine Institute of Volcanology and Seismology-Department of Science and Technology (DOST-PHIVOLCS), Buco, Talisay, Batangas, Philippines

This study reconstructs the 12 January 2020 Taal Volcano eruption through the analysis of narratives from two perspectives: those of the Taal Volcano Island (TVI) residents and those living along the Taal Caldera Lakeshore (TCLS). Personal accounts of TVI residents provide an up-close look at the volcano's behavior from the day before the eruption to the escalation of volcanic activity until the early morning after the eruption. These also include information on individual actions that helped lead to community evacuation. The decisions and resulting actions of TVI residents highlight the importance of alertness to observations of changing volcano behavior (environmental cues) based on local knowledge and long-established communication between the monitoring agency and the residents who had trust in the received warning message during the unfolding event. These paved the way for the quick action of the residents to evacuate at the most critical time. Interviews of eyewitnesses from TCLS on the other hand suggest a spectator's first reaction to watching the motorized outrigger boats as TVI residents evacuated (social cues), waiting before taking action to evacuate themselves. While various information and education efforts were conducted in the years leading to the 2020 event, the lack of experiential knowledge among the lakeshore residents and the fact that Taal did not have any major eruption in more than 40 years mainly contributed to their hesitancy to immediately evacuate, and not until the eruption occurred.

KEYWORDS

Taal Volcano, narratives, eruptions, evacuation, decision-making, phenomenology

1 Introduction

This work presents the sequence of events and actions based on eyewitnesses' accounts of the 12 January 2020 Taal Volcano eruption from two perspectives: those of the Taal Volcano Island (TVI) residents and those along Taal Caldera Lakeshore (TCLS) (Figures 1A,B). Personal accounts of TVI residents and interviews with TCLS

residents provide an up-close look and a spectator's first reaction, respectively, to the volcano's behavior from the day before the eruption to the escalation of volcanic activity until the early morning after the eruption. This study explores the experiences of individuals faced with an escalating volcanic event and their evacuation decision-making.

Quantitative studies on understanding the perception and coping strategies of populations living on volcanoes with a history of destructive eruption have remained limited, for example, the work on Vesuvius (Barberi et al., 2008; Carlino et al., 2008) and Campi Flegrei (Ricci et al., 2013) both in Naples, Italy, and Popocatepetl, Mexico (Lopez-Vasquez, 2009). For Vesuvius, a survey covered all towns around the volcano, and major findings indicate that the respondents had generally realistic views about the risk, including the recognition that an eruption with serious impacts was likely, which is a reason to worry about the threat. Despite this, there is still a lack of knowledge about the emergency plan and a lack of confidence in public officials among the respondents (Barberi et al., 2008). Another study on Vesuvius focused on a smaller sample of students from three towns, and findings suggest that respondents have an accurate perception of the level of volcanic risks, but lack an understanding of the volcanic processes and related hazards (Carlino et al., 2008). At Popocatepetl Volcano, Mexico, people exposed to volcanic hazards are faced with uncertainty but live with the risks as part of the daily condition to which they adapt (similar to those of the residents of TVI). The people living within the zone nearest to the volcano perceived volcanic risk as most worrisome, and a high percentage of these people who are exposed to the risk feel unprepared in case of an eruptive event and do not possess a coping strategy (Lopez-Vasquez, 2009). The last major eruption of Campi Flegrei, Naples, was in CE1538. There were also episodes of seismic activity, and the most recent one was in 1982–1984. In the survey, most respondents mentioned crimes, traffic, trash, and unemployment as major issues faced by their community. While volcanic hazards were not spontaneously mentioned, when asked specific questions about volcanic risk, the survey results indicated that people believed that an eruption with serious impacts was likely (Ricci et al., 2013).

One of the earliest works on evacuation decisions during volcanic eruptions identified that seeing the evidence of the threat, being advised by officials and relatives to leave, and seeing neighbors or relatives leave are the most critical factors cited for the decision to evacuate (Perry, 1983). Case studies on decision-making and evacuation behaviors during actual

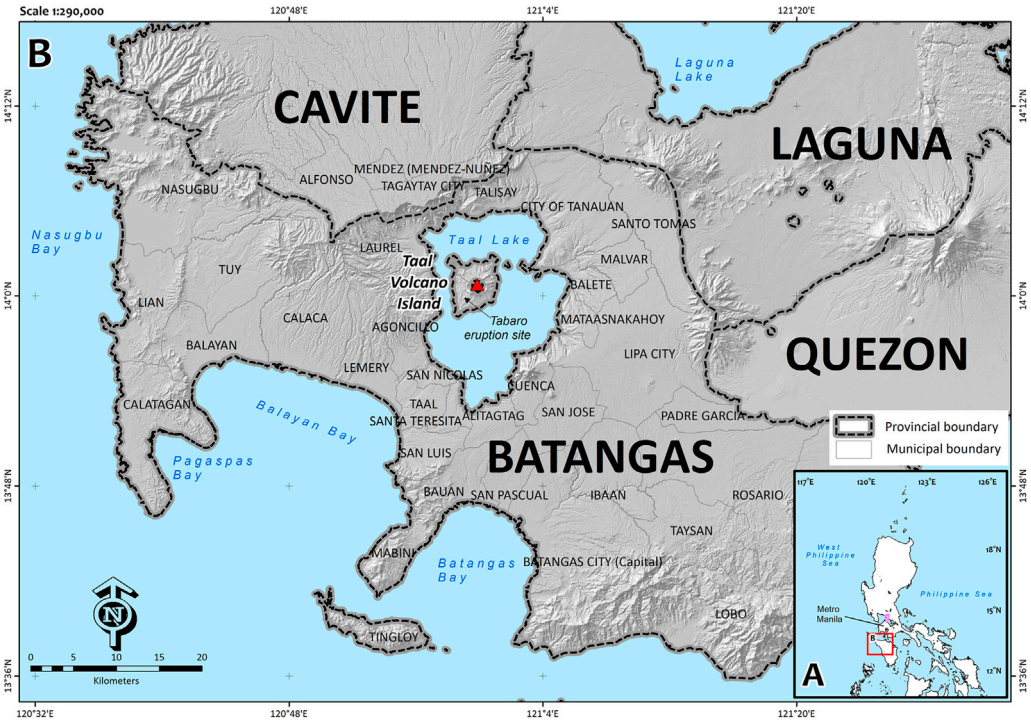

FIGURE 1
Inset **(A)** location of Taal Volcano about 65 km south of Metro Manila. A closer look at **(B)** Taal Volcano Island (TVI) within the Taal Caldera and the municipalities and cities of Cavite and Batangas Provinces around the caldera. The 1965 Tabaro eruption site in the southwest flank is also indicated. Neighboring provinces (Cavite, Laguna, and Quezon) making up Region IVA to which Batangas Province belongs are also shown. Data sources: the base map is an interferometric synthetic aperture radar–digital terrain model (IfSAR-DTM) from NAMRIA, 2013; administrative boundaries are adopted from PSA, 2016.

volcanic unrest have been conducted for Karthala Volcano in Comoros (Morin and Lavigne, 2009), Merapi (Mei and Lavigne 2012; Mei et al., 2013), Kelut, (De Belizal et al., 2012), Sinabung and Kelut (Andreastuti et al., 2019), all in Indonesia, and Mayon Volcano in the Philippines (Martinez-Villegas et al., 2021). These studies looked at the relationships between preparedness and response of authorities and evacuation behaviors of residents. Regarding behaviors, decision-making, and evacuations, recent studies in volcanology recognize and highlight the role of knowledge gained from prior experiences and its importance as a factor that motivates preparedness and influences decision-making (Barclay et al., 2019; Naismith et al., 2020; Bankoff et al., 2021).

Lechner and Rouleau (2019) studied the 2010 eruption of Pacaya Volcano, Guatemala, and found that factors affecting evacuation decisions include the respondents' capabilities (health, physical safety, and having a safe place to go), official warning messages, and direct cues of an impending disaster. A similar type of work was carried out for the 2010 Eyjafjallajokull volcano in Iceland (Bird and Gisladottir, 2018). Both works directly used the Protective Action Decision Model (PADM) (Lindell and Perry, 2012) as a theoretical perspective to understand the decision-making process and evacuation behaviors during volcanic unrest. It was pointed out that transmitted warnings or exposure to evacuation messages and environmental and social cues are the most important drivers of protective action decision-making.

Specific to the Taal January 2020 event, Prasetyo et al. (2021) conducted a quantitative survey that determined the relationship of identified factors affecting response action such as asset damage, eruption characteristics, disaster experience, socio-demographic characteristics, evacuation characteristics, and perceived severity using structural equation modeling (SEM). A related study by Kurata et al. (2022) determined the factors affecting preparedness beliefs among Filipinos on risks from Taal Volcano, and their findings showed that perceived risk proximity, media, and hazard knowledge have significant effects on perceived severity and vulnerability. In turn, perceived severity and vulnerability have a positive direct impact on perceived behavioral control, risk avoidance norms, and attitude toward the behavior. These were found to have direct significance to evacuation intention, preparedness behaviors, and beliefs. Lim et al. (2022) conducted modeling of evacuation behavior and planning for logistics focusing on one community (a barangay) in Talisay, Batangas, with evacuation decision and type of evacuation, the timing of evacuation, mode of evacuation, and destination as the main elements of evacuation logistics.

For this study, we aim to establish the sequence of events during January 2020 unrest and eruption, and then analyze individual observations and evacuation decision-making as a direct response in the face of an actual eruption. This is a significant contribution to understanding individual evacuation actions that lead to collective evacuation during a volcano crisis in the context of the Philippines setting.

2 Background

2.1 Taal Volcano's past eruptions and unrest

Taal Volcano Island (TVI) (14° 0′ 36.8634″ N, 120° 59' 53.232" E) is located in Batangas Province, which is 65 km south of Manila (Figure 1A). A multi-vent island volcano, TVI is situated in the middle of the Taal Lake, which is confined within a 25 km × 30 km-wide volcano edifice known as the Taal Caldera (TC) (Figure 1B). Before the 12 January 2020 eruption, Taal Volcano had 33 known historical eruptions, 24 of which were confirmed based on a recent review of available documents (Delos Reyes et al., 2018). The eruptions in 1749, 1754, 1911, and 1965 are categorized as violent with Volcanic Explosivity Index (VEI) between 3 and 5 (Delos Reyes et al., 2018). These events produced pyroclastic density currents (base surges) that traveled over the Taal Lake, devastating the communities of Agoncillo and Laurel, located west of TVI (Ruelo, 1983). Both the 1754 and 1911 events occurred in the Taal Main Crater (TMC), while the 1965 event occurred at a new eruption site, Tabaro in the southwest of TVI (Figure 1B).

Since its last eruption in 1977, at least 20 episodes of unrest that did not culminate in eruptions have been documented (Delos Reyes et al., 2018), for example, October–November 1987, August 1988, June–October 1989, March–July 1991, February 1992, April 1993, February 1994, September–November 2004, January–February 2005, November 2005, January–November 2006, and October 2017 to cite some. These were characterized by increased seismic activities, TMC temperatures, gas emissions, fissuring, and geyser activity, leading to an increase and decrease in the alert level status on several occasions. The latest unrest episode necessitated an increase of the alert level status to 1 on 28 March 2019.

In its history, major Taal eruptive events (e.g., 1754, 1911, and 1965) have forced people to leave the area. An example is the noted decrease in population following the 1754 event (Maso, 1911); however, people eventually returned and inhabited not only the lakeshore but also TVI (PHIVOLCS, 1992). The TVI population has continued to grow, from 1,830 inhabitants in 1977, to 3,628 in 1988, to more than 5,800 in March 1991 (PHIVOLCS, 1992). By the time of the 2020 event, the population was estimated to be higher than 6,427, which was the recorded population in 2018 (Batangas PDRRMC, 2018). In addition, Taal has become a popular tourist destination, and data on visitors from Talisay alone suggest that the number of visitors has increased from an annual count of 59,000 in 2011 (Vista and

Rosenberger, 2015) to 209,000 in 2019 (Talisay Municipality Tourism Office, communication 2022).

2.2 Local government structure, relevant laws, and disaster risk reduction for Taal Volcano

As per governance structure, the Philippines is divided into 81 provinces (political units, headed by the governor), and each province has a capital city and several municipalities (headed by a mayor). The general administrative reference to a province, city, or municipality is the local government unit (LGU, referring to province- and municipality/city-level political units). The governors and mayors are elected officials with a 3-year term, and LGUs have local autonomy. A city or municipality is further divided into smaller communities or village units called *barangays*, headed by an elected village chief referred to as *kapitan*. For the clusters of houses in TVI (that is under the responsibility of specific barangays), we also note the presence of unofficially elected but recognized community leaders. In addition, although provinces are divided and clustered to form the 17 regions of the Philippines, the regional-level organization is mostly responsible for the coordination of planning and delivery of national government services, rather than political-administrative jurisdiction. Batangas Province belongs to Region IVA composed of the provinces of Cavite, Laguna, Batangas, Rizal, and Quezon (Figure 1B).

The enactment of the Philippine Disaster Law of 2010 or Republic Act (RA) 10121 on Disaster Risk Reduction and Management (DRRM) ensured the creation of the Provincial Disaster Risk Reduction and Management Office (PDRRMO, disaster management office); thus, the Batangas PDRRMO was established. The law mandates that all LGUs, in this case, the Batangas Provincial Government through its disaster management office, take the lead in preparing for, responding to, and recovering from the effects of any disaster. The Batangas disaster management office is responsible for the preparation of the Batangas Province Disaster Risk Reduction and Management Plan and the Contingency Plan for Taal Volcano Eruption (CPTVE) (Batangas PDRRMC, 2017; Batangas PDRRMC, 2018). In the CPTVE, for each of the alert levels, the DRRMOs (local disaster management offices) have outlined actions to be undertaken (Supplementary Table S1) such as initiating a response.

There are ten municipalities (Talisay, Laurel, Agoncillo, San Nicolas, Sana Teresita, Alitagtag, Cuenca, Lipa, Mataas na Kahoy, and Balete) and two cities (Tanauan and Lipa) of Batangas around Taal Caldera Lake. Each city/municipality LGU is also required to prepare a local city- or municipal-level DRRM Plan, and establish a DRRM office with a 24/7 Emergency Operations Center (EOC). For inter-province coordination purposes, there exists a Regional Disaster Risk Reduction and Management Council (RDRRMC), with the Regional Office of Civil Defense (ROCD) as chair of the council. The episodes of unrest between 1991 and 2019 prompted the conduct of information education activities in LGUs and the selection of pilot sites for community preparedness. The activities include the conduct of evacuation drills for LGUs in collaboration with local government agencies (Supplementary Table S2).

In 1967, 2 years after the 1965 eruption, under Presidential Proclamation (PP) No. 235, Taal Volcano Island (TVI) was identified and declared *"reserved for park site purposes"* and stated that TVI is hereby *"withdrawn from entry, sale, settlement, or other disposition and reserve for park site purposes under the administration of Parks and Wildlife."* In 1992, another law RA 7586 was enacted creating the National Integrated Protected Areas System (NIPAS) followed by RA 7623 which declared Taal Volcano Island a tourist zone, and planning of tourism development and management of related activities became the joint jurisdiction of the Department of Tourism (DOT), the Department of Environment and Natural Resources (DENR), and the municipalities of Laurel, Balete, Agoncillo, San Nicolas, and Talisay. Presidential Proclamation (PP) No. 906 amended the 1967 PP No. 235, further defining the coverage of the protected area and creating the Taal Volcano Protected Landscape (TVPL). This facilitated planned and monitored tourism activities in the area. The organized tourism activities would also contribute to ensuring the safety of tourists on 12 January 2020 (Supplementary Table S3).

2.3 PHIVOLCS, Taal Volcano hazard map for base surge and volcano alert level

The Philippine Institute of Volcanology and Seismology of the Department of Science and Technology (DOST-PHIVOLCS, from hereon will be referred to as PHIVOLCS in this article) based in Quezon City (QC) is the national government agency mandated to study and monitor volcanoes, issue warnings, and operate and maintain the multi-parameter monitoring network of Taal Volcano (Supplementary Figure S1). The Taal Volcano Observatory (TVO) located in Buco, Talisay, Batangas, serves as its onsite monitoring operations center and is manned 24/7 by PHIVOLCS staff. In addition to monitoring duties, the TVO staff members also represent PHIVOLCS in DRRM Councils and are frontliners for relationship building and engagement with the local communities.

In 1992, PHIVOLCS generated the earliest version of Taal Volcano hazard maps (PHIVOLCS, 1992). However, with the results from more recent studies and available technology such as geographic information system to simulate modeling and higher resolution imageries and topographic maps, the latest version of the Taal Volcano Base Surge Hazard Map was generated by PHIVOLCS in 2011 (Figure 2). In this hazard map, PHIVOLCS identified areas that could be affected by base surges and included

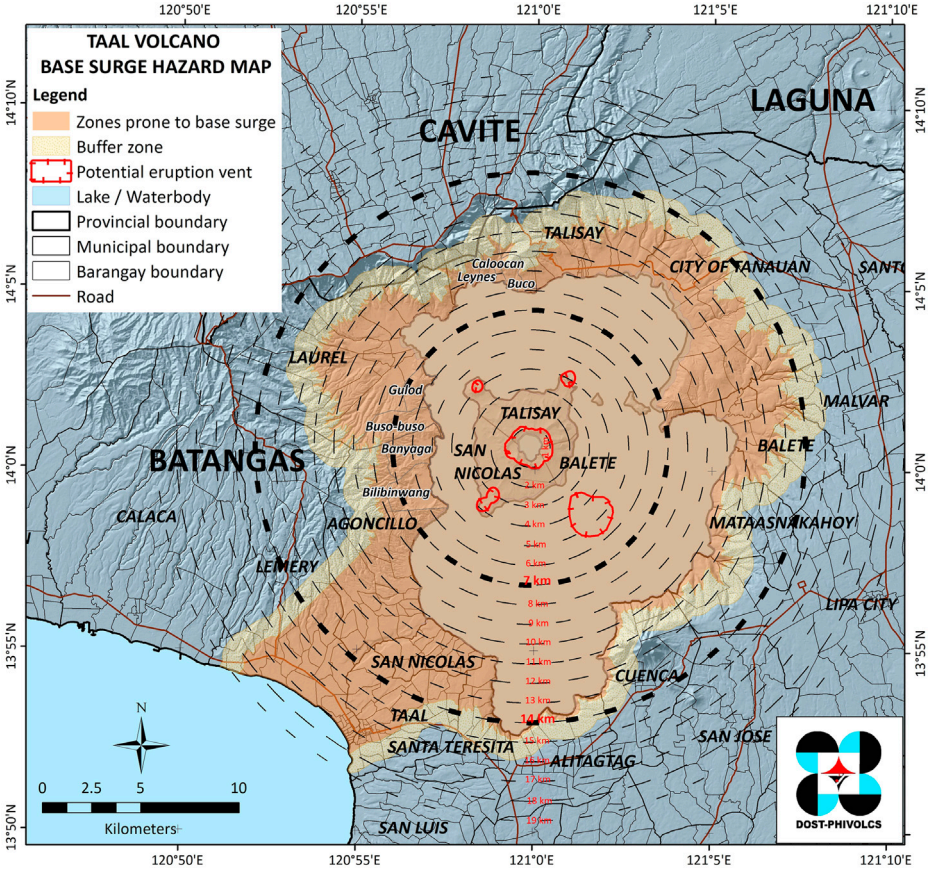

FIGURE 2
Taal Volcano Base Surge Hazard Map with kilometer radius (broken lines) from Taal Volcano Island (TVI) Main Crater Lake (MCL). The whole of TVI is declared as the permanent danger zone (PDZ). The base surge hazard zone (dark orange) is shown and buffer zones marked out at 1-km aerial distance from the hazard zone limits as additional precautionary zones. In the Taal Volcano Bulletin, the high-risk barangays of Agoncillo and Laurel within 7 km radius include Banyaga, Bilibinwang, Busobuso, and portions of Gulod. Due to the short distance from TVI, these lakeshore barangays west of TVI have historically been affected by base surges in 1754, 1911, and 1965. Lakeshore barangays Buco, Caloocan, and Leynes, all in Talisay, are also indicated for reference. Data sources: danger zone from PHIVOLCS, 2011 modeling; the base map is an interferometric synthetic aperture radar–digital terrain model (IfSAR-DTM) from National Mapping and Resource Information Authority (NAMRIA 2013) and Department of Public Works and Highways (DPWH). Administrative boundaries are adopted from Philippine Statistics Authority (PSA 2016) Map, which also shows the municipalities around Taal Caldera. Road Data (2015) and DOST-PHIVOLCS.

a kilometer radius as a guide for the distance from the main crater. Similar to the other provinces with active monitored volcanoes, the hazard map was provided to the Batangas' province- and municipal-level disaster management offices, and was referred to in their DRRM Plan 2017–2022 (Batangas PDRRMC, 2017) and Taal Volcano Contingency Plan 2018 (Batangas PDRRMC, 2018).

The PHIVOLCS as a monitoring agency releases bulletins and advisories on the status of a volcano. These are immediately sent to the NDRRMC for wider dissemination to the public. PHIVOLCS also maintains an official website and social media accounts where various types of information are immediately posted. Recommended actions in case of renewed Taal Volcano activity were introduced as early as 1980 in a document called Operation Taal (COMVOL, 1980). Within this old document is the description of "phases of volcano activity," which was replaced by the 6-level scheme of the volcano alert level (VAL) (from alert level 0 to alert level 5) as was introduced in 1992. The Taal VAL has evolved through time after review and reassessment, often following an episode of unrest, and it was the 2015 version that was used until the 2020 eruption. With both the Taal Volcano hazard map and volcano alert level provided to the local disaster offices, these were references for the crafting of the local government unit (LGU) DRRM and Contingency Plans. For each of the alert levels, there is a corresponding action in the LGU-prepared DRRM plan (Supplementary Table S1). When the PHIVOLCS increased the alert level to 1 on 28 March 2019, the released bulletin reiterated that TVI was a permanent danger zone (PDZ) and enforcement of off-limits into the TMC. The PDRRMO and TVPL subscribed to the recommendations of no

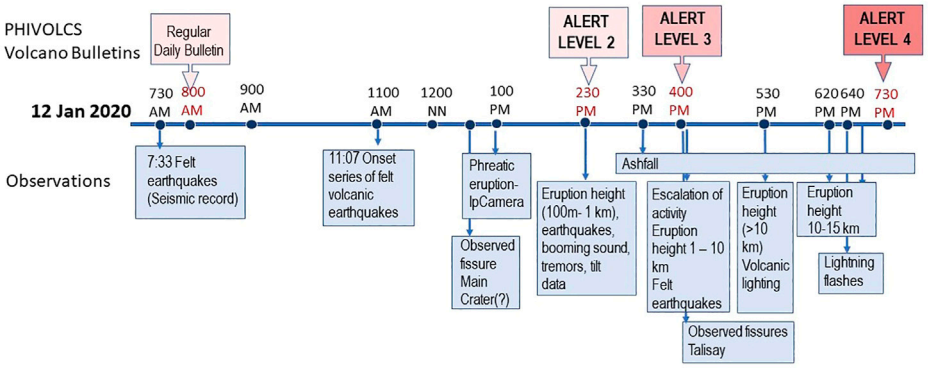

FIGURE 3
Reconstructed timeline of 12 January 2020 based on instrumental data (from PHIVOLCS-VMEPD), timing of releases of Taal Volcano Bulletins and reported observations from the felt earthquakes that increased in frequency, the fissuring inside the Taal Main Crater, and observed explosion and increased volume of plume that turned from white to dark gray as it developed into an eruption column with heights reaching more than 15 km.

entry to the main crater and thermal areas, but the municipal disaster offices continued with tourism activities up to view decks or crater rim only, adhering to the no entry into the main crater recommendation.

With episodes of unrest through the years, awareness seminars, volcano evacuation drills, and other exercises were conducted by the local disaster management offices (Supplementary Table S2). PHIVOLCS and Batangas local disaster management offices have also established a working relationship at various levels.

2.4 The 12 January 2020 eruption timeline including impacts: management of the crisis

On 12 January 2020, Taal Volcano in Batangas Province, Philippines, erupted after 43 years. On the day before the main eruption phase, bursts of volcanic earthquakes were recorded by the Taal Volcano seismic network as early as 7:33 a.m. (local time). These were accompanied by weak ground shaking felt by residents of TVI, escalating by 11:07 a.m. By 1:00 p.m. (local time), a phreatic explosion occurred in the fumaroles area located on the northeast shore of Main Crater Lake (MCL). An IP camera located inside the Main Crater (MC) captured the activity of the sudden occurrence of white steam that quickly progressed to the vigorous ejection of darker plumes until the camera was damaged by the eruption (PHIVOLCS, 2020). With the rapid escalation of the event, PHIVOLCS raised the alert level from alert level 1 to alert level 2 at 2:30 p.m. (PHIVOLCS 2020a). The activity transitioned to phreatomagmatic eruption possibly between 2: 34 p.m. and 2:40 p.m., based on PHIVOLCS IP camera images. By 4:00 p.m., the alert level was raised to alert level 3 (PHIVOLCS 2020b), and evacuation was recommended for areas identified as high risk. The eruption column height continued to increase, which was estimated to have reached more than 10 km between 5:30 p.m.–6:30 p.m. A quick response team (QRT) from PHIVOLCS-Quezon City was mobilized as reinforcement to the TVO staff. At around 7:30 p.m., the activity produced an eruption column of more than 15 km and volcanic lightning. Wet, heavy ashfall was experienced in most of the northeastern Taal municipalities surrounding Taal Caldera and the neighboring provinces of Cavite, Laguna, and Quezon (PHIVOLCS, 2020) (Figure 1B) The prevailing northward wind direction brought light ashfall to Metro Manila and as far as the province of Bulacan to the north (PHIVOLCS, 2020; Balangue-Tarriela et al., 2022). Concurrently, the alert level was raised to alert level 4 (PHIVOLCS 2020c) and expanded evacuation was recommended to include areas identified to be within the base surge hazard zone and 14-km radius (Figure 3) (Supplementary Table S4). As discussed in Section 2.2, in the Philippine DRR System, PHIVOLCS is the national agency that studies and monitors volcanoes, manages information about a volcano's status, and issues warnings during unrest. The LGUs plan and prepare during quiet times and respond accordingly during unrest.

The identified *"high-risk barangays of Agoncillo and Laurel"* mentioned in the alert level 3 are the areas within the base surge zone and fall within the 7-km radius, these are Barangays, Bilibinwang and Banyaga (Agoncillo), and Busobuso and Gulod (Laurel) (Figure 2). Due to the short distance from TVI, these lakeshore barangays, west of TVI, have historically been affected by base surges in 1754, 1911, and 1965 (Delos Reyes et al., 2018) and were pre-identified.

The component analysis of the 2020 tephra fall samples collected showed lithic (some hydrothermally altered) and volcanic rock fragments mixed with free crystals. The tephra fell in clumps, and the presence of accretionary lapilli supports

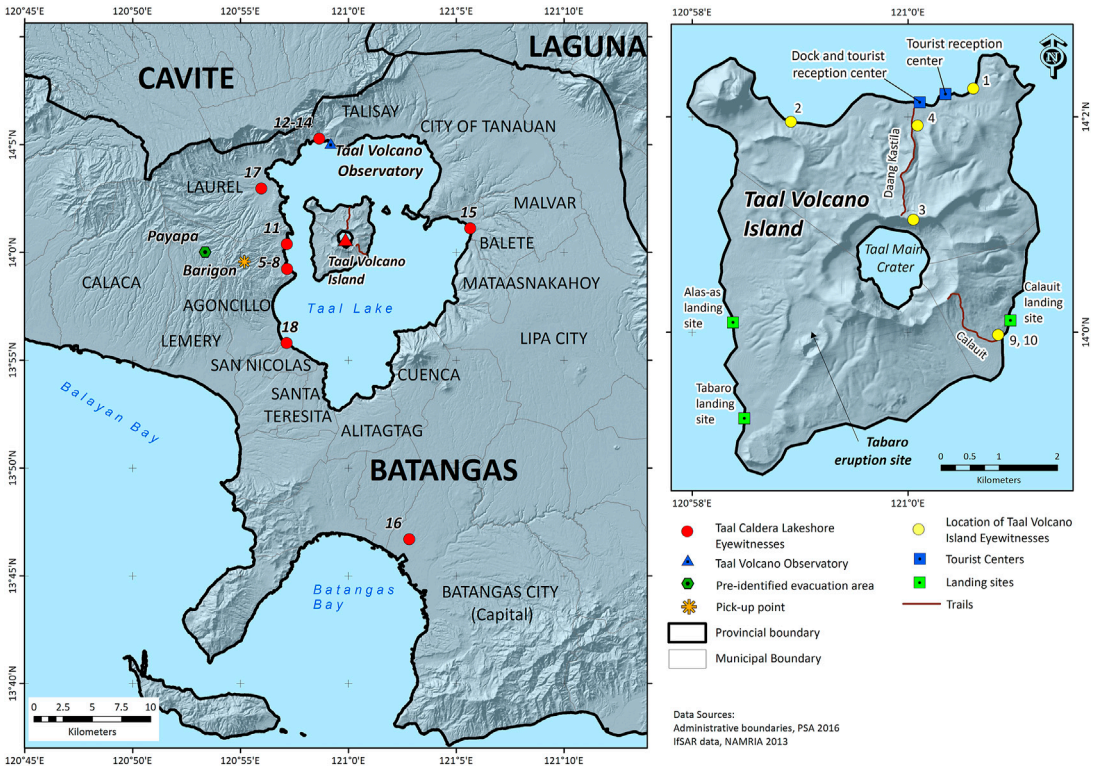

FIGURE 4
Approximate locations of eyewitnesses for this study. Excerpts presented in this study were from interviews of people from TVI and selected interviews from lakeshore communities of Agoncillo and Talisay. See Table 1 for list of eyewitnesses interviewed. Pre-2020 eruption, from the lakeshore, the take-off points of tourists are Talisay and San Nicolas and established landing sites for TVI tourist visits as take-off points for hiking are the tourist reception centers north (using the Daang Kastila trail to hike to TMC), southeast (using the Calauit trail to hike to the TMC), and southwest (for a hike to the 1965 Tabaro eruption site). Data sources: the base map is an interferometric synthetic aperture radar–digital terrain model (IfSAR-DTM) from National Mapping and Resource Information Authority (NAMRIA) 2013; administrative boundaries are adopted from Philippine Statistics Authority (PSA), 2016.

the initial reports of the phreatomagmatic nature of the event starting at 4:00 p.m. (Balangue-Tarriela et al., 2022).

Stratigraphic and component analyses of deposits collected during fieldwork on TVI, conducted a year after the January 2020 eruption, provide confirmation of the sequence of events starting from the phreatic nature of the first few hours of the event (Lagmay et al., 2021). The event that escalated and transitioned to a phreatomagmatic eruption in the late afternoon, developed an ash column attaining the heights of 10–15 km. Based on the review and analysis of crowd-sourced images and videos, the maximum height reached was between 17 and 21 km by 8:00 p.m. (Lagmay et al., 2021). The eruption produced deposits described as base surges, which formed a field of pyroclastic dunes with cross-bedding structures, with a maximum thickness of 12 m (average of 4.7 m) proximal to the crater, and 5.8 m maximum (0.9 m average) in the lower slopes near the coast. The estimated volume of the deposits is 19 ± 3 million m^3. Components of the deposits include accretionary lapilli, abundant juveniles, and accidental clasts, consistent with the phreatomagmatic nature of the event (Lagmay et al., 2021).

3 Materials and methods

We interviewed eyewitnesses to the 2020 eruption during fieldwork conducted from March 2 to 6, 2020. The purpose of the study is to document the experiences and capture the stories as told from the lens of eyewitnesses. We used purposive sampling and focused on finding people who 1) experienced the event and 2) could describe their experiences in detail. We looked for interviewees who were on TVI during the event and who were in contact with the TVO staff as the event unfolded. We interviewed eyewitnesses from the TCLS with whom we have previously engaged as they held positions in their *barangay* for a community-based preparedness-related project implemented between 2014 and 2019 and focused on the municipalities of Talisay and Agoncillo. Interviews with two officials from the

TABLE 1 List of interviewed eyewitnesses used in this article. Location is indicated in Figure 4.

	Code	Sex	Age	Location on 12 January 2020	Occupation
1	TA-TVI2020-M	M	60	Tabla, Taal Volcano Island	Community leader and local business owner
2	SI-TVI2020-M	M	57	San Isidro, Taal Volcano Island	Community leader and local business owner
3	MC-TVI2020-M	M	39	Main Crater Rim, Taal Volcano Island	Tourist guide
4	DK-TVI2020-F	F	43	Daang Kastila, Taal Volcano Island	Tourist guide
5	BI1-TCLS2020-M	M	57	Bilibinwang, Agoncillo	Barangay leader
6	BI2-TCLS2020-F	F	45	Bilibinwang, Agoncillo	Resident
7	BI3-TCLS2020-F	F	55	Bilibinwang, Agoncillo	Resident
8	BI4-TCLS2020-F	F	52	Bilibinwang, Agoncillo	Resident
9	CA1-TVI2020-F	F	55	Calauit, Taal Volcano Island	Resident and local business owner
10	CA2-TVI2020-M	M	56	Calauit, Taal Volcano Island	Resident and local business owner
11	BA-TCLS2020-M	M	Nd	Banyaga, Agoncillo	Barangay leader
12	LE1-TCLS2020-M	M	70	Leynes, Talisay	Barangay leader
13	LE2-TCLS2020-F	F	58	Leynes, Talisay	Resident
14	LE3-TCLS2020-M	M	43	Leynes, Talisay	Resident
15	BC1-TCLS2020-M	M	58	Batangas City	DRR official
16	BC2-TCLS2020-F	F	53	Batangas City	DRR official
17	LA-TCLS2020-F	F	Nd	Laurel	DRR official
18	SN-TCLS2020-F	F	29	San Nicolas	DRR official

province and two officials from two municipal disaster management offices (one an additional interview *via* Zoom in July 2022) were also used for validation of timelines of actions. The purpose of the study was explained to the interviewees, and formal consent was obtained by having them sign a consent form. Figure 4 shows the approximate location of the eyewitnesses during the eruption period. The list of eyewitnesses is presented in Table 1 in coded information for private reasons as required by the Philippine Law RA 100173 or the Data Privacy Act of 2012. To distinguish the male from female eyewitnesses, -M or -F was added to the coded identity. After the March 2020 field data collection, the team intended to do another series of surveys in other parts of the area, but this was postponed following the lockdown imposed starting on 15 March 2020 due to the rapid spread of COVID-19. With the prolonged lockdowns and associated uncertainties throughout 2020–2021, the additional survey could not be conducted anymore. Follow-up for clarifications with interviewees, however, was conducted through phone calls and SMS. The results of this study will be an important point of discussion when presented to the local disaster management offices.

Data collection was performed using a semi-structured interview approach, with some open-ended questions so the eyewitnesses could elaborate on their personal experiences. The video-recorded interviews were transcribed and then analyzed qualitatively. In the review of transcriptions, the purpose was not only to determine the timing of the stories but also the statements were further examined and categorized. Selected excerpts were further analyzed and counterchecked with accounts of other eyewitnesses to establish how the stories are connected and tied up together. Small group discussions with local officials of two selected communities (locally known as *barangay*) were also conducted.

Data from interviews of 18 eyewitnesses were used in this study. In addition, the names of PHIVOLCS TVO staff mentioned in the interviews were also coded when presented in the succeeding sections. Some details if specifically mentioned during the interview were marked out using xxx, for example, personal information. Selected portions of the interviews were translated into English for presenting in this article. For purposes of maintaining the essence of the local language description, the authors have opted to retain and present some words in the local language (*Tagalog*) as used in the descriptions. In the translation, we used the communicative approach to reproduce as precisely as possible the contextual meanings of the words within the constraints of the target language's grammatical structure (Newmark, 1988).

As supporting materials for validation and cross-confirmation of the timing of actions, short message service (SMS) or text messages and phone call logs, whenever still available, were requested from and graciously provided by the eyewitnesses. We also validated the narratives with the official records and volcano monitoring data and confirmation through verbal communication with TVO staff.

In this study, we used phenomenology and narratives analysis. Phenomenology as a philosophical approach is the nature of meaning that people construct in their lives and that guides their actions, and in this construction of meaning, an individual's beliefs and desires are implied (McPhail, 1995; Van Manen 2020). Phenomenology is the study of how things appear, are given, or are presented to us (Van Manen and Van Manen, 2014). It is concerned with stories of experience from the perspective of the individual (Lester 1999; Pietkiewicz and Smith 2012; Tembo 2016; Qutoshi 2018). As a research method, phenomenology explores the essence of a phenomenon from the perspectives of those who experienced the event. The goal is to describe the meaning of this experience: what was experienced, and how it was experienced (Neubauer et al., 2019).

Related to this, narratives analysis is the study of human experience involving a retelling of an event (Clandinin and Huber, 2014) using interviews as a data collection tool (Connely and Clandinin, 1990). In narratives, the eyewitnesses are requested to recount and narrate the experiences of the event just as it happened (Sandelowski 1991). Narratives are stories people tell about their lives (Gray et al., 2005)—in this case, the Taal Volcano eruption—as eyewitnesses experienced. This narrative approach enables us to analyze how human beings typically understand and represent their own lives and experiences. We look at narrative analysis and phenomenology as a valuable combined approach to support risk communication research by understanding how to learn from the experiences of others.

4 Data and results

The narratives were divided into two sets of eyewitness perspectives: those who were on TVI as the event unfolded and those who witnessed the event from the shores of the Taal Caldera Lake (TCL). During the review of transcribed interviews, three major categories of descriptions were identified. These include 1) environmental cues mostly from observations during the morning of 12 January, 2) observations of social cues from evacuation experiences, and 3) communication during the event. The narratives are presented as much as possible in a chronological manner, and Philippine local time was used.

4.1 Environmental cues: observations on 12 January 2020

On 12 January 2020, an early Sunday morning, the tourist activity, especially the visit to TVI, was already in full swing. An initial query about a felt earthquake was received by TVO staff, which was forwarded for verification. There had been felt earthquakes occasionally in the past; however, tourist guides and residents on TVI noticed an increasing frequency of felt earthquakes that are locally referred to as "*burog*" or ground shaking, and that was accompanied by subterranean sounds according to local descriptions.

4.1.1 Burog: increasing frequency and strength of felt earthquakes

"*Burog*" is a local term that is used by the people on TVI to describe felt earthquake events accompanied by rumbling sounds they associate with volcanic activity. Three of the eyewitnesses, one working as a tourist guide (DK-TVI2020-F) and the two other business owners (SI-TVI2020-M and CA-TVI2020-F) on the volcano island, narrated that they started to feel earthquakes, which they observed to increase in frequency and strength as time went by.

> It started at 7:00 in the morning. It was a succession (of earthquakes). Just about when I was going down. We hiked down, we arrived at 10:30. We were waiting at the loading area because most of the guests were there. We noticed (the shaking) and wondered—what was that? It was frequent. Then, that was it, I sent text messages to him (TVO1), I said, Oy, how many have you recorded there?—DK-TVI2020-F.

> I arrived in Pulo (TVI) by 7:30. It was around 9:00(?), there was an earthquake, it was weak. By 10:00, it became frequent, minutes (interval)...then by 11:00, by the seconds ... continuously, I told my man, I will call Sir TVO2. I reported, "Sir TVO2, it is becoming frequent here. That was around 11:00.—SI-TVI2020-M.

> We did not see anything, but there was ground shaking (burog). Then, that morning, ... around 10:00–11:00. I sat down. Well, why is it ...the ground shaking (burog) seemed different or unusual, I said. My godchild called and said, "please call PHIVOLCS because I have received text messages here that in Ilaya, they can feel it, the ground shaking (*burog*) is not stopping." So, I called TVO3.—CA1-TVI2020-F.

We note that the estimates in timing varied, but we cross-checked with the narratives and instrumental data for confirmation to come up with the general timeline (Figure 3). There are three important details from these excerpts. First, on the location, the first two eyewitnesses were on the northern side of the volcano island (Figure 4), while the third eyewitness was located on the southern side and had no view of the crater. Second, the three were consistent with descriptions of discrete but felt earthquakes locally referred to as *burog* that became frequent from 11:00 a.m. onward. Third, all three mentioned directly communicating with TVO personnel to confirm what they felt onsite. According to the TVO staff, it has become the practice of the people of TVI to inquire or report *via* SMS or

phone call to TVO staff of felt earthquakes for years due to previous years' unrest.

4.1.2 Increase in the volume of steaming and the "bitak" or ground fissuring inside the Main Crater

As the event continued to unfold, the occasional but discrete felt earthquakes became more frequent. One eyewitness (MC-TVI2020-M), a tourist guide stationed at the Taal Main Crater (TMC) view deck (Figure 4), and recalled how he saw the fissuring inside the crater. Using rough sketches of the crater on paper during the interview, he pointed to the approximate location as he narrated:

> Then suddenly they screamed. When I looked, it turned out, they were retreating. I looked there inside the crater (a hand gesture, demonstrating relative position) to the west, e when I looked inside the crater, e the steam (*usok*) was so vigorous on this side (pointing, hand gesture). It cracked (*bumitak*), which was the first to crack open, so the people were screaming. Maybe it was around 12:30 p.m. That was the time, around 12:30 p.m. It became stronger, there was steaming . . . Some panicked, like the vendor, the runners who were taking photographs. When they looked up, they screamed and then scampered, running away as the ground cracked open (*bumitak*). The strong steam (*usok*) was coming from the crater here (hand gesture demonstrating direction) on the east side. The voluminous steaming (*pinakamalaking usok*) coming from the big hole (*butas*) before it cracked open (*bago bumitak*).—MC-TVI2020-M

Residents around Taal in their daily-used language refer to the volcanic steam and plume they see as *usok*. This local word, depending on context and usage, can either mean smoke from a burning matter or steam from boiling water (Almario, 2010).

For most of the descriptions in the succeeding sections, we focus on two perspectives—first is the recollections of those who immediately evacuated from TVI and reached the safety of the lakeshore across, and second, the actions of residents of the Taal Caldera Lakeshore (TCLS) communities based on eyewitnesses' stories. Their observations of the changing character of the steam plume and experiences of ashfall and ground fissures are presented.

4.1.3 From vigorous white steam to growing gray ash plume or column

From the following excerpts, the change in color of the steam from white to dark gray as it developed into an eruption column was observed as the TVI residents were evacuating on their outrigger boats to cross the Taal Caldera Lake (TCL).

> We were in the middle of the lake. We were midway, the steam (*usok*) continued to go up from the main crater, and grew bigger. It was still white. When we reached Talisay, it has turned dark . . . so there was ash, dust (*alikabok, gabok?*) we were just in time. When it turned dark maybe around 2:00 p.m., when it turned dark. Then it grew bigger and bigger. Like the whole mouth of the crater was filled. –SI-TVI2020-M.

> The color was still normal - white. Then, it (the steam) became stronger (while we were crossing), as if . . . the steam (usok) became taller and rose above the crater rim- MC-TVI2020-M.

> Yes, slowly it went up. At first, it was light-colored, white. It was not dark yet. Then after some time, it was like a flower that started blooming, growing. It kept on growing, and it changed color to dirty white. Yes as time went by, the steam grew bigger. –DK-TVI2020-F.

As the event progressed, the white *usok* (steam) description changed as it became voluminous, together with a color change to gray or black, indicating the presence of ash. At this point, the eyewitnesses were describing the eruption column.

4.1.4 Putik at buga: rain of mud and fragmented volcanic rocks

Tephra (fine to coarse fragments of volcanic rocks) started falling by 2:00 to 3:00 PM. Those who immediately fled from TVI recall that they have not noticed the tephra fall until they reached the shores of Talisay. Most described observing the change in the character of the ash *(abo)*, from fine materials (*pino*) to mud *(putik)*, and observing fragments they refer to as "*buga*." *Buga* is a local word for rocks around Taal described by people, referring to the small fragments of dark volcanic rocks with holes to which the equivalent technical term in volcanology is scoria.

> When the rocks started falling, we were at the Baywalk (Talisay). The ash (*abo*) came first. All of us were at the Baywalk. Then, at around 4:00 p.m., it was wet. The ash was wet and smelled. When it fell on the leaves, there was a slight smoke because it was hot. –SI-TVI2020-M.

> Then, it rained with mud (*putik*)... I guess it was past 3:00 p.m. Around 3:30 or 4 p.m... I could not see across anymore. It was dark. Maybe that was when it exploded up there - just where the horses used to pass by. –MC-TVI2020-M.

> When it started, when it changed color to dark and increased in height . . . it was probably around 2:00 p.m. It became dark...then there were scoria fragments (*buga*). Scoria (*buga*) were falling all around us. That was maybe 2:00 p.m. Some of the scoria (*buga*) was big. There were fine ones...then some said, to take a look at the lakewater so you can see as they fall,

> how the scoria fragments (*buga*) fall onto the water . . .. Because as I told them, it (ash column) spread toward here, it was above us, you can see how it spread, there was lightning . . . there was lightning there somewhere over the volcano. It was good the wind was blowing east, and towards Tagaytay. The truth is, a lot of mud (putik) fell on many places in Tagaytay. –LE1-TCLS2020-M.

The change in character, based on the description from "*pino*" (fine dust) to "*putik*" (mud), confirms the wet nature of eruption (phreatic-phreatomagmatic), and the appearance of "*buga*," the local word used to refer to scoria (suggesting larger-sized fragments), confirms the transition to the phreatomagmatic nature of the event from the initial phreatic phase. Then, visibility started to decrease, making it difficult for people to move around, further slowing the evacuation.

4.1.5 Reported ground fissures in two lakeshore communities

Starting in the late afternoon, observations of ground fissures were first reported in Talisay (SI-TVI2020-M). Based on BA-TCLS2020-M, ground fissures in Agoncillo appeared much later, most probably into the night.

> While we were in Talisay, by 4:00 p.m., people were getting ready. The Mayor said, go to the gym, that is where they (evacuees) will be picked up to go to the evacuation. When we went to the gym, there were fissures (*bumitak*); it was late in the afternoon, maybe around 3:00 p.m. when the fissures appeared (*bumitak*), and people got scared. Yes, there was a fissure (*bitak*) on the ground...and (the shaking) was continuous... then it would become strong... so there was like around 2 feet that the other side of the ground went down. –SI-TVI2020-M.

> (in Agoncillo) None yet. I was driving back and forth on this road with my vehicle . . . then I saw that (fissure)... but that part where it tilted . . . it was at night, I'm sure it was at night. –BA-TCLS2020-M.

4.2 Social cues: experiences during an actual evacuation

The following are descriptions of the reactions and actions of the TVI and TCLS residents based on eyewitnesses' stories.

4.2.1 Leaving the Taal Volcano Island

This section has significant documentation of the individual actions of the eyewitnesses while leaving TVI, and how TVI residents operating the tourism business ensured that the tourists were brought to safety.

> E, so soon after, most of the people started crossing the lake. The tanod (designated village security officer), because of the tourism activity of the people, xxxx of Tourism asked them to wait around. "Do not leave while there are still tourists, due to their safety, you have a responsibility to them if any of those will be left behind." That was around 1:30 p.m. I stayed behind. The tanod also stayed behind. Of course, we are leaders. When we saw that it was getting stronger. It was still white, it was still white. When we were midway—the steam/volcanic plume (*usok*) was already very tall...What the people did, it was okay. They were not in a panic because of quick action. There was no panic in people. There were many available outrigger boats, but we did not know how many because it was more than what we needed to ride. So, it was a big help. So whatever happens, at the quickest time, we can leave. We can leave. –SI-TVI2020-M.

> So, what I did, my children were still there, so I called for them. I told them to cross (to the mainland), as they said it is going to erupt (puputok na), it was steaming (*nausok na*). E we did not believe as it's been this way - with earthquakes (*naburog*), but we were convinced when some tourists who went up earlier to the volcano came back, as they could not proceed because of the steam (*usok*). So around 1:00 p.m. . . . and TVO3 said it is different now. No (couldn't see the volcano from their location), but we saw the steam (*usok*) as it was very high. –CA1-TVI2020-F.

As the event continued to unfold, the following further describes the actions of *MC-TVI2020-M* and *DK-TVI2020-F*.

> I did not believe it, then they screamed, so I looked - and the steam (*usok*) was strong, the fissure (*bitak*) was huge, and the steaming became strong. E, the people started running, like the tourists, but, there were still many, so I told them, "Go ahead, go down now" to all the people I was able to talk to at the crater rim. Confusion and chaos had started. Some tourist guides hesitated, that they might earn the ire of tourists if they did not proceed...some attempted to proceed, but not long after, they came back. So, when I started to go back, it was probably around 1:00 p.m...When we finally started moving to go down, there were just a few of us. I was with my wife and first-born son. I told him we need to buy gasoline as we need to cross the lake. Then kapitan called, and he said "Get ready as the people have started crossing (to the other side of the lake). So, as soon as we were able to get down, I bought gasoline and could see many outrigger boats have started crossing. He (kapitan) left later than I did. I went ahead of him as my boat is smaller, and his boat is bigger. –MC-TVI2020M.

> By that time, it felt like the shaking (yanig) just kept on going and wouldn't stop, while I was preparing my clothes. Then

> my husband said that they will tether the horse and my nephew who lives with us, told him to not do this anymore, as the ground was already shaking. My husband asked if there's a provision for them to feed on. So I helped him, but we have only tied one of the horses, while my nephew frantically ran down to the shore to lower our boat. So, we were able to go down quarter to one, we were able to tie four of our horses while the others remained near the house. E, so, by 1:30 p.m., I called my son for us to meet by the shore because the boat is ready - we have a small one for the family not for tourist business. So, by quarter past two, we were already here in Buco. We were able to get here by past two. –DK-TVI2020F.

These accounts point out to various environmental cues that the TVI residents heeded. The narratives of SI-TVI2020-M and MC-TVI2020-M also emphasize the responsibility of tourist guides toward the island visitors.

4.2.2 Evacuation of residents in the lakeshore communities

As mentioned, the TCLS eyewitnesses in Agoncillo and Talisay did not feel the *burog*; instead, they saw 1) motorized outrigger boats full of people leaving the TVI and 2) the white steam/plume coming from the TMC when it was already big enough to be visible, that is, with its height above the crater rim and developing into a tall dark eruption column. The following excerpts were from eyewitnesses from Banyaga (BA-TCLS2020-M) and Bilibinwang (BI1-TCLS2020-M), Agoncillo (east caldera lakeshore). The descriptions were mostly on the observed social cues followed by environmental cues that prompted them to immediately take their actions.

> "It was around 1:00 p.m. when I woke up. I woke up, then had my coffee. Not long after, the children arrived.

> "*Tatay* (grandfather), it looks like the volcano erupted, there's plenty of steam (usok)." I said, "Maybe someone is just burning stuff there."

> E, I still went out and I saw that it was huge. I said to myself this is for real...it is not a joke. E so, the people, I said for them to go up - the people on motorbikes were coming, with their family, brought with them clothes. It was around 2:00 p.m. in the afternoon.

> "Go upslope, to the mountain, go to Bilog, Maasim, straight to Marigold."

> I was still there; I did not leave until around 3:00 p.m. Yes, they went up immediately. It was around three. I said P*$#% #, there seem to be no more people running around, like no more human movement around. Which meant, they already left. It was so fast, the ash column. There were a few people... I called one councilor, I said, where are you. He said *Kap* we already left. I said those people are now there. They were gone, they all left. Some were in Kuskusan, for as long as they are up there, some were in Marigold. So, that' when I stopped. I took my vehicle to leave with my family. –BA-TCLS2020-M.

> I could see the steam (*usok*) as it started to grow big. So I called TVO1. I think it was around 2:30–2:45 p.m. "Sir, what is the status of our volcano? Why are the people from the island leaving..." They were doing pre-emptive evacuation. When the people started leaving, it was about 3:00 p.m. I looked back, wow, it was huge by this time, so I told my colleagues... The steam (*usok*) has become big. It also turned dark, and that's when I decided. I told the councilors to inform the people and ask people to evacuate as this will definitely go on and erupt...So they were here. I told them to use their motorcycles. So they told the people to evacuate (*lumikas na kayo*). We did not feel (any earthquakes). . . It was 3:00 p.m... and by 4:00 p.m. it was already huge... and it was already black and tall. By 4 o'clock many were already in xxxxx (author's note: pre-determined evacuation area for the *barangay*) ...but others were in different places...different people... no, each individual decided on their own. –BI1-TCLS2020-M.

Meanwhile, from Leynes, Talisay, the eyewitnesses (LE1-TCLS2020-M; LE3-TCLS2020-M) described how they observed as people watched from the shore and waited. It was only much later that Talisay TCLS residents started moving.

> It was huge, but it was not very tall yet . . . we did not feel anything. It was all steam (*usok*) that we could see....then the tourists started returning as they were told not to proceed. . . Those who were supposed to go there before noon were turned back. Those on the island, they said they really felt . . . they were the ones who felt the shaking, they said they felt even the roofs of their houses, and there was this sound–rumbling (*naugong pa*)... But here, there was none... nothing here... it was normal, it seemed everything was normal . . . But we started making the rounds. We went to TVO to ask what alert level was there before we started... –LE1- TCLS2020-M.

> The people were still talking to one another and looking on. We already gave advice to get their belongings. –LE3-TCLS2020-M.

> There were many tourists there, and they came back... but they stayed by the lakeside, looking on, taking videos (of the volcano island)... e, so we advised them. Yes to prepare for evacuation because it was not... and all of us here now, we said- "why all should leave, why are the young people still

> here." We did not say more as we were told it was Level 2 only... they were not even asking what level it is... we just advised them... –LE1-TCLS 2020-M.

As a consequence of the reaction, it became more difficult to leave due to poor visibility as the ashfall intensified.

> One problem that resulted is we had to ferry people back and forth...and I had to comment and remind some of those that "and you still roam around when you know that the volcano is erupting. "I asked them "Where are you going." They said they were about to go home to xxx, and there were some explosions and rain of rocks. Their main problem at that time was that there was no available transportation (bus) to take. So people took action on their own. Yes, there was some transportation for the evacuees...but it was only up to the town proper.

> So, the problem that arose, we could not see, was zero. It was already zero visibility, after the scoria (*buga*) mixed with mud (putik) that were falling and that was around 5... those onlookers who were here, left around 2:00 p.m. going up to Payapa, but they were caught until nightfall in heavy traffic along the way and were still on the road until night. People with vehicles went on their own. So what we did, was we brought the elderlies and children upslope, the others did not reach the site until 7:00 p.m.—LE1-TCLS 2020-M.

Based on these recollections of eyewitnesses, residents of Banyaga and Bilibinwang, Agoncillo, immediately left once the environmental cues were observed, unlike the residents of Talisay who, even with observed cues and reminders from *barangay* officials, remained for a while. From the descriptions and news reports, the overall evacuation of TCLS was slow (Delica-Willison, 2020) because by the time they evacuated, TCLS residents (such as Talisay) were already caught in the middle of heavy ash fall.

4.2.3 More observations of the unfolding event: early morning of 13 January

In Talisay, two eyewitnesses (DK-TVI2020-F and TA-TVI2020-M), who came from TVI stayed behind. They felt safe, for their house was located upslope. TA-TVI2020-M stayed behind to monitor the situation. However, as night time came, they experienced the following:

> "We did not want to leave, because they said, we are safe because our place is high. But then by 3 a.m. in the morning... first, around 2:00 p.m., it was very strong. So by 3:00 a.m., we peeked, and we saw. We wondered, why? There was fire as it was exploding this way (hand gesture). The fire was like it spread up. There was strong shaking, so we got nervous, as there was already fire. We said, if this will continue with this fire, of course, it was scary that we might not be able to evacuate anymore. –DK-TVI2020-F.

> It was 2 a.m. in the morning, Monday. We were in Barangay xxxx, which is part of Tanauan (Figure 1), well, I said there was another one because it exploded. Around 2 a.m. in the morning, we asked to be rescued. Then when we arrived, there was another explosion because we felt it, Sir. There was another explosion because we felt. Sir, it was far. We still felt it. We felt the shaking, so I said, there was another one that followed after 2 a.m. in the morning. –TA -TVI2020-M.

> Ay, there was sound. It was night. That was midnight when it started shaking, around 12 noon (how about earlier, around 6 in the evening?) None yet...it was from midnight onward until 3:00 a.m. There, it was like a fast up-down/dribbling motion (*nililiglig*). Like this (motion-demonstrates with hand gesture in quick up-down motion). . .it was fast, fast. Maybe around fifteen (15) to twenty (20) minutes in the state. Here, you can hear the roof –LE3-TCLS2020-M.

All three mentioned the heightened activity, especially the felt earthquakes starting at almost midnight until around 3:00 a.m. in the morning unlike during the morning of 12 January when *burog* was felt by those in TVI. By this time, volcanic quakes were felt even by those that remained in the lakeshore communities. This appears to be the final intense phase of the eruption based on instrumental data.

4.3 Communication between Taal Volcano Observatory and Taal Volcano Island and other officials

One important detail is the direct link between the TVI residents with the PHIVOLCS TVO staff. This relationship was built up through the years. The TVO staff were accessible to the local people through mobile phones, and it proved to be a very important link during this critical period.

4.3.1 Proactive, direct communication established long before the event

The established communication between TVO and TVI residents was made possible through years of interaction during field observations, surveys, and regular equipment maintenance works conducted in TVI. For years, the TVO personnel maintained direct communication with residents of TVI so that when something unusual was felt or observed, these residents would initiate sending messages or calling a TVO staff member to confirm if there were events detected by the PHIVOLCS seismic instruments, or the TVO staff member on duty would call residents in TVI to ask if they felt an earthquake in their locations, thus serving as field validators.

Part of the regular interactions would be a reiteration of reminders to be vigilant at all times and to not hesitate to leave the island in case of any alarming observations. According to SI-TVI-2020-M, a small business owner and local community leader, they have established relationships to quote, "*A long time ago. We go back in time. Yes, Sir TVO3, with Sir TVO2, Sir TVO1. With Sir TVO2, we always, every day, communicate with us, updating us . . . Our leader reminded us, to get ready, if the earthquakes continue, if it becomes frequent, we have to evacuate. We should be certain.. because that's the reminder of Sir TVO2.*"

4.3.2 Call to evacuate and actions

The first to evacuate were those from TVI. Based on the narratives of the eyewitnesses, the felt earthquakes heightened their concern, which prompted a call to TVO1 (SI-TVI2020-M). Some residents were already preparing to evacuate even before the call from any TVO staff and most residents of TVI evacuated on their own.

> "That's it, during the first time it shook when the shaking was strong- I talked to Sir TVO1, with our barangay tanod, the councilors. I said, "Chief, please do a house to house." To think it was very hot from the market to the school, 362 houses in all. I said, "If there are no vehicles, go to my house, before you leave, and ask all the tourists to leave before you come down." I told the tanod on the view deck. –SI-TVI2020-M.

> " The reason I called was, it (earthquakes) increased and became stronger. My chickens, were cackling. My wife said, can you please call, please call our barangay chief and councilor, I told them, please that even if PHIVOLCS has not made any announcement, we are asking all to evacuate. When the village tanod started doing this, I called Sir TVO2. He said, "If you are quick *Kap*, please ask them to evacuate (lumikas), by whatever means..." –SITVI2020-M.

> (upon feeling the shaking) Yes, I was sitting right there, where you are now, I leaped to my feet, wondering, I said, "Why is it like this? Isn't it . . . "

> After a while, TVO3 called, and he said "Dxxx, where is your (husband). . . please be ready, as we are to go on Alert 2" he told us. "Where is *Kapitan*?" to which I replied, "He is here."

> "Please give (the phone) to *kapitan*." So I gave the phone to him.

> So, they talked to each other, and TVO3 said "Evacuate (*palikasin*--) the people", So, that was it...E, so he started calling (*Kap*) but by that time, the others have already left. It was around 1 p.m. –CA1- TVI 2020-F.

> Yes, at around 11:30, around noon, a, it was prohibited by the people who are in charge at the pier by xxx, that no one will be allowed to go/hike up to the –DK-TVI 2020-F.

These communications from TVO were also confirmed by four local disaster management officials who were interviewed regarding the actions taken at the DRRMO level. Although listed in Table 1, they will be referred to as *DRR1*, *DRR2*, *DRR3*, and *DRR4*.

Between 1:00–2:00 p.m., DRR1 of TCLS was outside the town and received an urgent message from the Mayor regarding the reported felt earthquakes at the TVI. DRR1 sent a text message to TVO1 who immediately called back to confirm the ongoing activity. TVO1 informed DRR1 of the possibility of the alert level being raised to Level 2. DRR1 immediately sent this information back to the Mayor and hurriedly returned to town. By the time DRR1 arrived roughly between 2:00 and 3:00 p.m., the Mayor with the chief of police, and their staff were already assisting the evacuation of people in the identified high-risk *barangays* within the 7-km radius, which was their priority. They were using megaphones. Almost all came forward to evacuate, but the evacuation process was scattered as most people had their own vehicles and went different ways, some going upslope (up the caldera wall). For the identified priority high-risk barangays (within 7 km), they did not have to go back to pick up people from this zone, as according to DRR1, these barangays were empty *("wala, wala, walang sinadya na balikan dahil wala nang tao doon")* by night time. A brief meeting on 12 January between 2:00 and 3:00 p.m. was convened but mostly for verbal instructions of taskings (Figure 5). It was on 13 January that the municipal disaster officers had to go back to the other *barangays* to pick up those who did not want to leave but were within the 7–14 km radius.

DRR2 was in Lemery when TVO1 called to inform about the ongoing activity of the volcano and advised that "*Alert Level will be increased any time soon if the current activity doesn't change.*" In addition, TVO1 mentioned that the community leaders have been informed about the developing activity. By the time DRR2 arrived onsite between 2:00 and 3:00 p.m., people on boats from TVI had arrived. A short meeting was convened by the Mayor in the municipal hall around 3: 00 p.m. for instructions. There were vehicles, but the DRRM officers were overwhelmed as there were very few staff members in the office. The Mayor's instructions to the *barangay kapitans* were clear: residents with no means of transportation should go to the main provincial road so that they can be picked up by vehicles passing out of the town. Although transportation to ferry people was limited, other towns were ready to assist and sent support vehicles. DRR2 noted that there were people who stood by the lakeshore to watch the event as it unfolded, especially in

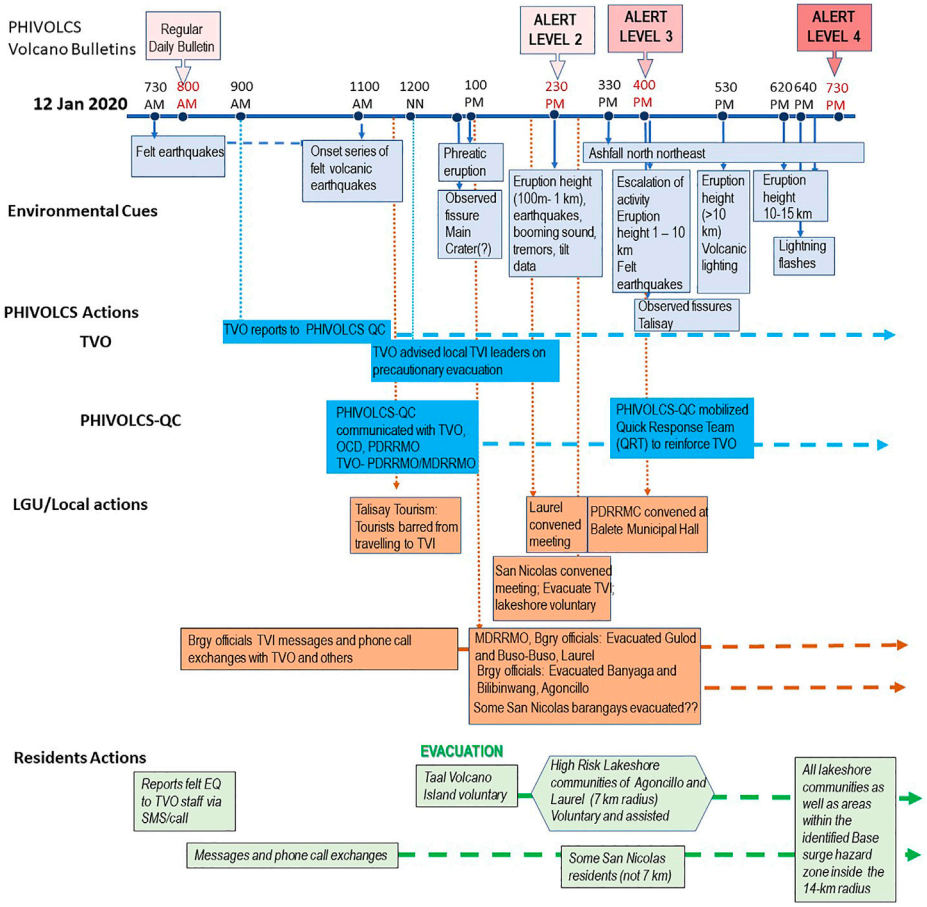

FIGURE 5
Expanded reconstructed timeline based on eyewitnesses' narratives showing temporal relationships of environmental cues, PHIVOLCS-QC (Quezon City), TVO actions, LGU/local actions and residents actions. Time estimates indicated are based on recollection of interviewees. Horizontal arrows with broken lines indicate additional actions during the ongoing event. Response/action of local disaster officers are based on interviews. Due to the accelerated pace of the event, all instructions from the LGUs for residents to evacuate were performed in real-time on the ground, without formal issuances based on accounts of DRR1, DRR2, and DRR3.

the beginning. However, those who were scared and able to leave evacuated voluntarily.

DRR3 also confirmed having direct communication (through a phone call) with TVO1 at 1:53 p.m. just before the 2:00 p.m. release of Taal Volcano Bulletin, during which TVO1 gave the advanced information that alert level 2 would be raised. DRR3 also received two additional phone calls from PHIVOLCS-QC at 3:39 p.m. and 3:51 p.m. for advanced information regarding the increase to alert level 3 through the Taal Volcano Bulletin that was released at 4:00 p.m. By this time, DRR3 was in touch with local disaster officers of other towns that have jurisdiction over TVI communities and received confirmation that the volcano island had been evacuated. DRR3 watched the growing tall and dark eruption column from the lakeshore and coordinated with other local disaster officials by phone calls. It was around this time at 4:00 p.m. that DRR3 was relieved to have received initial reports (from Talisay and Balete) that the TVI had been completely evacuated and that this was carried out in such a short period. According to DRR3, one Mayor commented that the growing height of the volcanic plume alarmed and put fear into the TVI residents, leading them to immediately leave the island. Their decision was reinforced after the information from TVO staff members.

Another phone call conversation between PHIVOLCS-QC and DRR3 took place just before the bulletin for the increase to alert level 4 was released at 7:30 p.m. In this Taal Volcano Bulletin, evacuation of areas up to a 14-m radius was recommended (Supplementary Table S1). According to DRR3, this was a moment of realization that adjustments had to be rapidly made as in their existing contingency plan, at alert level 3,

they were prepared for additional areas between 7 and 10 km only. According to DRR3 and DRR4, they were overwhelmed as they had to move additional people farther, but by this time, they received support from the Philippine National Police (PNP) and the Philippine Coast Guard (PCG) to help in the evacuation.

Separately, from their emergency operations center (EOC), DRR4 had been monitoring the PHIVOLCS website and social media for updates, as soon as various reports about the unrest or activity at TVI were received at around 2:00 p.m. Albeit difficult to connect, DRR4 also confirmed a phone call conversation with TVO1 at 2:09 p.m. after the official bulletin was already released on the PHIVOLCS sites. Their EOC continued and were kept occupied with coordination for the mobilization of support, anticipating the need to assist and augment operations of the affected municipalities, especially when the alert level was raised to Level 3 by 4:00 p.m.

All three local disaster officers (DRR1, DRR2, and DRR3) mentioned that due to the fast-paced nature of the situation, most instructions for evacuation were verbal and no documentation of these DRRMO meetings was prepared.

5 Discussion

For this study of the Taal Volcano January 2020 event, the initial purpose is to determine the sequence of actions as the volcano's status escalated. We focused on reconstructing the event as experienced by eyewitnesses and examined in detail the possible factors leading to evacuation decisions.

5.1 Reconstructed timeline for 12 January 2020

From the list of physically observable signs of unrest shown in Figures 3, 5, the expanded reconstructed timeline from the eyewitnesses' accounts showing temporal relationships of the environmental cues, and the actions of the four 4) main groups of actors: PHIVOLCS-QC (Quezon City); TVO; LGU/local officials; and residents, are presented. The detailed content of the bulletins released is presented in Supplementary Table S4. The TVO staff members who had direct contact with 2 local leaders (TA-TVI2020-M and SI-TVI2020-M) starting at 12:00 noon provided verbal advise that the Alert Level should be raised, and this served as the final push for the action of TVI residents, who were getting ready to evacuate when the environmental cues started to escalate. Based on the timeline, the Taal Volcano Bulletin was released at 2:30 p.m., but by this time, most TVI residents had already crossed over to the lakeshore.

Meanwhile, as the Taal volcano activity further escalated, the residents of the lakeshore communities were alerted by the movement of boats loaded with TVI residents, as well as the already visible growing and darkening volcanic plume. The Taal Volcano Bulletin raising the Alert Level from 2 to 3 was released at 4:00 p.m., identifying high-risk barangays (Taal lakeshore communities within the 7-km radius) for evacuation. The local emergency operation centers were activated. By 7:30 p.m., with the release of the Taal Volcano Bulletin, the recommended evacuation zone was expanded to cover a 14-km radius when the alert level was increased to Level 4.

Eyewitnesses' accounts were validated against the timing established from the PHIVOLCS Volcano Monitoring Division instrumental data. It is important to be able to put in as much documentation from the local government units concerned for relevant data on the details of the evacuation process. However, as mentioned in Section 4.3.2, according to the municipal disaster officials we interviewed, most actions were through direct verbal instructions as soon as the emergency plans were activated. Based on the interviews, meetings were briefly convened by the province- and two municipal-level disaster offices, but these were undocumented (no minutes of meetings or memo issuances). Due to the accelerated pace of the event, all instructions from the LGUs for the residents to evacuate were done in real-time on the ground, without formal issuances based on accounts of DRR2, DRR2, DRR3, and DRR4. In retrospect, the direct link between TVO and TVI residents and some local disaster officials became very limited. The focus of the communication during the initial stages of the crisis was on relaying critical information between TVO and TVI. The implementation of evacuation for TVI was accomplished at a rapid pace, and to some extent, the same can be said for the high-risk coastal communities within 7 km when the alert was raised to level 3. However, the local disaster officials were overwhelmed by the succession of events, especially with the 7:30 p.m. release of the Taal Volcano Bulletin and the recommendation for evacuation of those within the 14-km radius. The communication to TCLS residents for evacuation within the 14-km radius had become more challenging given the situation that people were still evacuating in the middle of tephra fall as night fell.

As per procedure, at the national level, information on the status of the volcano went directly to the NDRRMC Operations Center through official channels of communication. A separate communication was sent to the provincial disaster management office. For wider public reach, the same information was simultaneously posted on the official website and social media accounts. In Albay, for each of the Mayon Volcano Bulletin issued by PHIVOLCS, a corresponding Albay PDRRMO issuance on instructions or directives is immediately released. However, Mayon Volcano has erupted several times in the last 50 years, and these eruptions provided the LGUs and residents around Mayon with more experiences and opportunities to improve their DRRM system. The outcome of these previous experiences is a better-trained system when emergency mode and

the DRRM and Contingency Plans are activated during volcanic unrest. Coordination between province-level and municipal-level disaster offices is clear and well-defined (Martinez-Villegas et al., 2021). For Batangas, except for the episodes of seismic swarms, the province never experienced an actual Taal Volcano eruption in the last 43 years. It is also noted that the quick pace and duration of a volcanic event are different for Taal. Although drills and exercises were conducted in previous years (Supplementary Table S2), these were still limited in scope. The existing DRRM and Contingency Plans were put to actual implementation and tested only during the 12 January 2020 event. This was evident during the 12 January 2020 response in terms of overall actions not only of the officials but of the residents as well, if we are to look at the details of mobilization and logistics (evacuation transportation and site management) (Delica-Willison, 2020; Lim et al., 2022).

5.2 Decision-making: environmental, social cues, and warning messages

For a rapidly developing situation such as the case of the Taal Volcano on 12 January 2020, the awareness of the TVI residents about the signs of volcanic unrest, and to act upon these environmental cues, mobilized people to action. We note that several eyewitnesses confirmed the residents' actions: others have decided, or have started preparing or were leaving TVI even before the call from any TVO staff members between 11:00 a.m. and 1:00 p.m. (*SI-TVI2020-M; CA1-TVI2020-F*). The Taal Volcano Bulletin was released at 2:30 p.m. The advanced information to TVI officials, barangay officials, and community leaders providing the warning message to evacuate before the bulletin was released *(lumikas/palikasin)* was one of the contributing factors that prompted the appropriate action to evacuate. There were also specific reminders that tourists waiting in Talisay dock to cross the lake were not allowed to proceed and that tourists on the island were to be assisted to leave before the tourist guides could evacuate themselves (*SI-TVI2020-M*).

5.2.1 Evacuation and location from the volcano

From the narratives, the reason to evacuate seems to be influenced by the location of eyewitnesses, especially their distance from the volcano. The residents of TVI (on ground zero) readily evacuated due to the observed environmental cues such as increased frequency of strong earthquakes accompanied by rumbling sounds *(burog)*, and increased volume of volcanic steam *(usok)* that changed color from white to gray or black. For the TCLS residents who were located across the volcano island, it is the observable gray-black volcanic plume coupled with the social cues (i.e., the observed evacuation of TVI residents on their boats) that prompted the initial evacuation for those who have the shortest distance from TVI to the lakeshore, especially for Bilibinwang and Banyaga *(BI1-TCLS2020-M and BA-TCLS2020-M)* earlier than the 4:00 p.m. release of Taal Volcano Bulletin increasing the alert to level 3. Despite the initial response of the TVI residents to voluntarily evacuate followed by lakeshore residents, especially those in the identified high-risk areas who started moving before the 4:00 p.m. release of the bulletin increasing the alert to level 3 (i.e., Section 4.2.2. Banyaga and Bilibinwang), and many other TCLS barangays remained.

The residents of the lakeshore *barangays* of Talisay, which received some of the early evacuees from TVI, did not seem to have the same response as some of the residents of Banyaga and Bilibinwang. Historically (1754, 1911, and 1965), Talisay was not impacted by the base surges, as its location is outside the 7-km radius. Residents of these other lakeshore *barangays* still waited for the raise to alert level 4, which was not until 7:30 p.m. This confirms the recent findings in a survey conducted on Taal that perceived risk proximity as a factor that contributes to behavior controls and risk avoidance, and these are significant to evacuation intention (Kurata et al., 2022). In addition, another study conducted on Taal suggests that evacuation characteristics (e.g., a pre-identified evacuation center near home, activated emergency response by officials) and eruption characteristics (e.g., distance from the volcano and minimal time to prepare for the volcanic eruption) were identified as important drivers for evacuation in the survey study conducted by Prasetyo et al. (2021). These identified factors are also consistent with what has been pointed out in another study on the reasons for evacuating as cited by respondents: seeing evidence of threat (which means seeing the eruption), being advised by officials, relatives urging them to evacuate, and seeing that neighbors or relatives left (Perry, 1983).

There is an interesting comparison that can be made from a study conducted by Martinez-Villegas et al. (2021) at Mayon Volcano on the views of residents about what to them is an eruption and when an event is threatening or dangerous. The study looked at how people developed their meanings of hazards and risks based on what they have experienced and observed over time. It is the eruptive events experienced in the past that shaped their views. Residents living on the slope of Mayon volcano wait for observed environmental cues, relating eruptions to *seeing* the *fire at the summit*, *feeling the strength of the explosion*, *relating to the presence of ash (how thick or thin?)*, *whether they feel weak or strong shaking*, or *whether they just hear breathing-like sounds or loud explosions*. Together with directives from their local disaster officers, these are also factors they consider in their decision to evacuate or remain (Martinez-Villegas et al., 2021). For this particular Taal Volcano event of 2020, even without prior experience of any actual eruption phenomena, the progressive changes in environmental cues were the factors in decision-making for TVI but apparently not for all of TCLS.

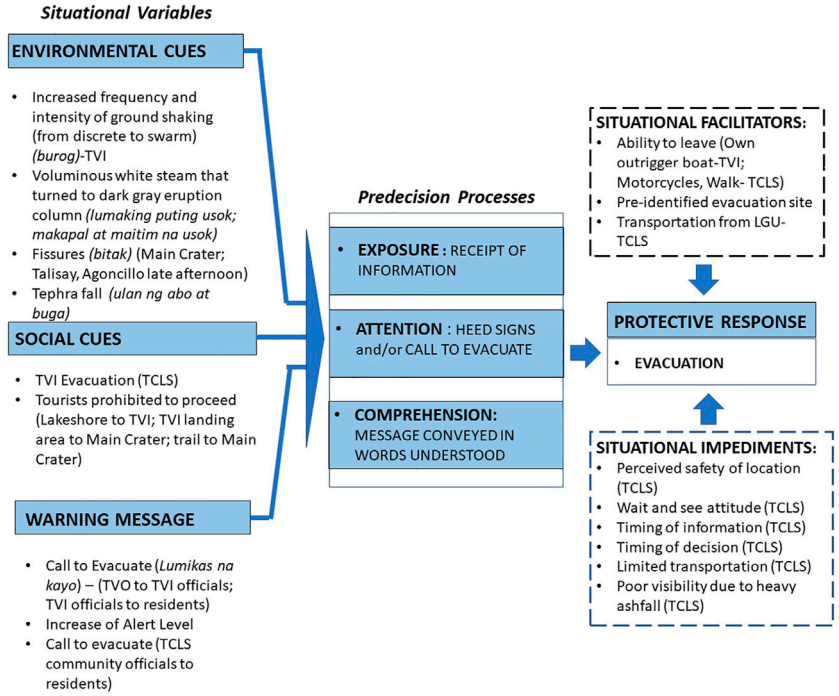

FIGURE 6
Summary presentation of the Protective Action Decision Model (PADM) adapted and modified from Lindell and Perry (2012) and Lechner and Rouleau (2019). For this work, we identified from the shared narratives' specific situational variables, situational facilitators, and impediments in the process that influenced evacuation as the outcome. TVI and TCLS indicate where each variable is attributed. We recognize there are still many other factors at play in an unfolding volcano crisis event and a more detailed study is recommended.

5.2.2 Protective action decision model: situational facilitators and impediments

These Taal 2020 eruption narratives of eyewitnesses, although few and limited, illustrate the individual decision-making process during an unfolding volcanic crisis. Considering that there was only one reported as a direct casualty (Ozaeta, 2020), the narratives presented gives glimpses of the process leading to a successful evacuation of the TVI residents and tourists (estimated at 6,000) on a volcano island during a rapidly escalating activity. When the alert levels were increased, the crisis expanded beyond TVI to include the evacuation of TCLS residents. Although apparently slow at the beginning as news reports indicated people evacuating in the middle of heavy ash fall (Delica-Willison, 2020), roughly 38,203 individuals from TVI and TCLS communities were moved to safety in various evacuation centers (NDRRMC, 2020). It is the combination of the early communication for TVI, environmental cues, and social cues that led to the evacuation. The step-by-step procedure for evacuation as written in the provincial-level plan needed adjustments. In retrospect, this is understandable considering the rapid escalation and the succession of raising of alert levels from two to four between 2:30 p.m. and 7:30 p.m. Still, the outcome of this event is an important baseline for the review and improvement of existing response plans and protocols during volcano-related events.

In these Taal 2020 interviews, we identified actual situational variables that fall into environmental and social cues following the Protective Action Decision Model, PADM (Lindell and Perry, 2012; Lecher and Rouleau, 2019). A summary of these identified variables, aligned with the PADM, is presented in Figure 6. In the PADM, the process is initiated by situational variables, environmental cues, social cues, and receipt of the warning message. In the case of Taal 2020, in the middle of an unfolding event, the decisions and resulting actions of TVI eyewitnesses highlight the importance of alertness to these environmental cues (various observations on changing volcano behavior). The received message to evacuate reinforced this instinctive decision to leave. This was also reinforced by trust in the received warning message during the unfolding event, a trust that was built on long-established communication between the monitoring agency (TVO staff) and the eyewitnesses.

For the TCLS eyewitnesses, it was seeing the evacuation from the TVI of people in outrigger boats that was the main social cue, and the observation of a voluminous dark eruption column, as an environmental cue, that finally led to the evacuation, and by this time, receipt of information about the alert level increase from

PHIVOLCS. In the decision-making process, there are identifiable situational facilitators. First, owning outrigger boats (for TVI residents), motorcycles, or even just being able to walk are variables that facilitate one's ability to evacuate. Those who could not leave had to wait for transportation from the local government. Having a more certain place to go to (whether to relatives or pre-identified evacuation sites) can also be another situational facilitator for decision-making.

For impediments (i.e., delayed or non-evacuation), we identified the residents' wait-and-see attitude, opting to watch the event as it unfolded. Another is the perceived safety of their location; for this case, moving upslope and away from the lakeshore part of the community (as referred to in Section 4.2.3). As presented, the eyewitnesses chose to stay behind instead of leaving on the night of 12 January. However, eventually, they became scared as they felt the strong shaking and heard the sound that went on through the last hours of the night until 3:00 a.m. (13 January). The local DRR officials described (e.g., in Section 4.3.2) their concern over the limited means of transportation, which further delayed evacuation (the province and neighboring towns provided additional trucks). Another impediment is the timing of information received. Those who waited for alert level 4 evacuated when it was already night time, coupled with heavy tephra fall, which is another physical impediment, that is, poor visibility. From the descriptions and news reports, the overall evacuation of TCLS was slow (Delica-Willison, 2020) because by the time they evacuated, the TCLS residents (such as Talisay) were already caught in the middle of heavy ash fall.

6 Concluding remarks

This study documented and analyzed eyewitnesses' narratives on the short-lived 12 January 2020 Taal Volcano eruption. To be able to capture these narratives, the study focused on finding eyewitnesses who were on the volcano island during the event and eyewitnesses from the lakeshore communities, and conducted a semi-structured interview approach. These recorded interviews were transcribed and qualitatively analyzed. Focusing on visual observations and actions of people, we were able to reconstruct the sequence of events in a rapidly unfolding volcanic crisis from the lens of the people who experienced the eruption.

From these eyewitnesses' accounts during the Taal Volcano 2020 eruption, the reasons and timing to evacuate seem to be influenced by the location of eyewitnesses, especially their distance from the volcano. The residents of TVI (on ground zero) readily evacuated due to the observed environmental cues such as increased frequency of strong earthquakes accompanied by rumbling sounds *(burog)* and increased volume of volcanic steam *(usok)* that changed color from white to gray or black. For the TCLS residents who were located across TVI, it is the combination of environmental cues (e.g., observable gray-black volcanic plume) coupled with the social cues, mainly the observed evacuation of TVI residents on their boats that influenced the decision to evacuate.

The evacuation to safety of the local people living in TVI together with the tourists who were on the island on 12 January can also be attributed to the quick thinking and decisive action of some of the TVI residents as described by the eyewitnesses. In addition, the established relationship and communication link between PHIVOLCS TVO staff members and the local government officials through long years of working together have built the trust in the received warning to immediately evacuate.

To most Batangas LGU and other government officials and residents, this was their first experience responding to an ongoing crisis related to a Taal Volcano eruption. The existing provincial and municipal DRRM plans had corresponding actions to each increase of the alert levels issued by PHIVOLCS, but the accelerated pace at which the event unfolded on 12 January required a fast-paced response as the local government activated their disaster response plan and deployed staff for various activities (e.g., to set up evacuation centers and to immediately provide transportation to the evacuees). A review and assessment of the pre-2020 plan as against the actual response, especially in the action per alert level, needs to be undertaken for enhancing and updating the LGU's DRRM and Contingency Plans. PHIVOLCS has already revised its Taal Volcano Alert Level Scheme as of June 2021, and this needs to be thoroughly rolled out to the various communities.

These data on the documentation of oral accounts of eyewitnesses were analyzed from the perspectives of eyewitnesses in TVI and the TCLS residents. This is a valuable dataset rich in descriptions not only of the volcano's behavior through time but also of individual actions. This is an add-on to the volcano history as the human dimension of the crisis is given as much focus.

Data availability statement

Data supporting this work specifically full transcriptions of the interviews are available at DOST-PHIVOLCS upon request and subject to agreements. The full names of all interviewees are tabulated and kept by the main author. The interviewees are coded and full names will not be available to any third party due to the Philippine Law Republic Act 10173 also known as Data Privacy Act. The law protects individuals from unauthorized processing of personal information.

Ethics statement

Ethical review and approval was not required for the study on human participants. The participants provided their written informed consent to participate in this study.

Author contributions

MM-V is the lead researcher, designed the study, interviewed eyewitnesses, analyzed the transcriptions, and led the writing of the manuscript. PR contributed to Sections 2.2, 4.2, and 5.1; provided additional documents; and continued on follow-ups of relevant documents from PDRRMO. LS and DD both interviewed eyewitnesses; AL, PR, and RS searched, recommended, and located eyewitnesses, provided critical communication data (phone logs, SMS messages), helped establish timelines during the data analysis, and followed up communication with interviewees. AP prepared all map figures used for this manuscript. All participated in discussions of the data, analyzed possible interpretations, and gave valuable insights about the event.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feart.2022.923224/full#supplementary-material

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