

# Perceptions and Response of Residents, Horse Guides and Tourists on Sudden Volcanic Disasters: Taal Volcano, Philippines

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**Abstract:-** Deaths and injuries due to sudden eruption of volcanoes have increased in recent times. While efforts to understand the mechanisms behind sudden eruptions is underway, it is important to understand the perceptions and response of people on this hazard. This paper seeks to understand the residents, horse guides, and tourists' perceptions on the hazards of sudden volcanic disasters in Taal volcano, their response and willingness to engage in mitigation initiatives. Results reveal that volcanic rocks of all sizes are the least known hazard among respondents as well as differences in responses on various sudden volcanic disasters. There is also a willingness to use and invest in mitigation actions within reasonable means.

**Keywords:-** Perception; Response; Sudden Eruptions, Volcano.

## I. INTRODUCTION

There are various hazards which can be attributed to the activity of volcanoes. Examples of these are pyroclastic flows and surges caused by eruption, earthquakes, landslides, tsunamis and mudflows. Eruptions become more complex when the surrounding population is dense or worse, if the behavior of volcanoes erupting suddenly which occur without warning to people. Table I. lists some of the most lethal sudden eruption cases worldwide, the worst being Japan's Mount Ontake where 35 people died, mostly hikers and tourists.

Year	Volcano & Country	Casualties/ Injuries
1990	Mt. Agua Shuca, El Salvador	25 dead, 15 injured
1993	Mt. Galeras, Colombia	9 dead (6 volcanologists, 3 tourists)
2014	Mt. Ontake, Japan	35 dead
2013	Mt. Mayon, Philippines	5 dead
2015	Mt. Hakone-Owakudani Japan	40 people evacuated
2017	Mt. Dieng, Indonesia	10 tourists injured
2020	White Island, New Zealand	6 dead, 20 injured

Table 1:- Sudden Volcanic Eruptions In The Past 30 Years [1] [6]

When an impending eruption happens, early warning and evacuation are necessary to mitigate risks and protect the people present in volcanic areas. In case of sudden eruptions, warning is difficult due to precursors. This is especially difficult as volcanic areas become highly populated [11][12] and become venues for industrial growth and eco-tourism where people are at close proximity of craters or possible eruption vents [10]. In relation, people have differences in their perception of volcanic risk based on various factors [3]. Studies on volcanic risk perception have been conducted since 1960s and proves to be a complex and continuously evolving field of study [5][8]. Most research on sudden eruptions focus on the mechanism and prediction strategies, and not much on mitigation of risks and how it affects people, especially how it impacts the tourism and small business industries affecting rural areas.

Thus, the purpose of this research is to explore the perception of risks against sudden or unexpected environmental disasters with a focus on volcanic hazards. The specific objectives are 1.) to find out the perception of residents, workers and tourists on volcanic hazards and their respective risks; 2.) to find out their actions on evacuation during a sudden volcanic eruption; and 3.) willingness in investing in protective gear for sudden volcanic hazards.

## II. METHODOLOGY

### A. Study Area

The area to be studied is in Taal volcanic area in Batangas province, Republic of the Philippines (Fig. 1). It is surrounded by provinces and local governments and the second most active volcano in the country and one of the Twelve Decade Volcanoes of the world cited by the International Association of Volcanology and Chemistry of the Earth's Interior or IAVCEI. The Decade volcanoes are those listed by the organizations which are needed to be studied because of their large eruptions in the past and high proximity to populated areas. It has a complex yet poor eruptive history [13] and prone to sudden phreatic (steam) eruptions [14]. The area is also a very popular place for tourism as hiking, fishing, sightseeing, malls and amusement parks as it is just two hours away from Metro Manila, the country's capital. The Taal volcanic island is where the main crater is located. The island centered by a lake formed by the Taal caldera where it has 47 eruptive centers underneath [9].

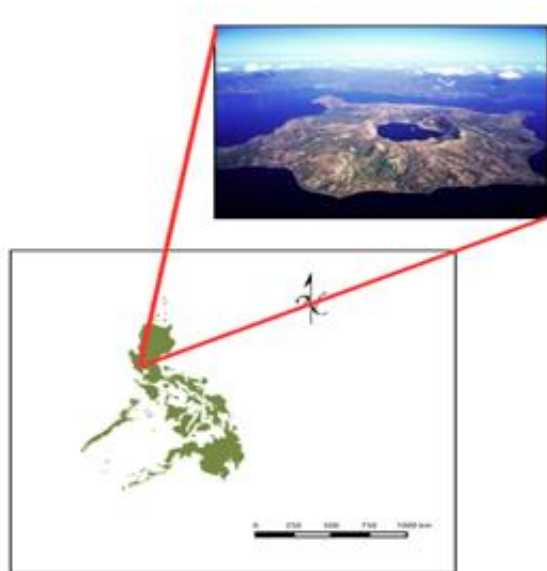


Fig 1:- Taal volcano island

### B. Data Collection and Analysis

One hundred (100) residents and workers of Barangay Tabla, Taal volcano island were randomly selected as respondents for the questionnaire survey. Most of the respondents were horse guides who live in the island. To assess the perception of non-residents and workers, fifty (50) tourists at the Taal crater, Taal volcano island using the Daang Kastila trail. The field survey was performed from the 28th to 30th of March 2018.

Risk perception survey questionnaire was performed to identify the residents and tourists' knowledge about volcanic hazards, and their actions in case a sudden eruption happens[2]. The questionnaire was divided into three categories:

- Hazard and risk perception: Respondents were asked about the types of primary and secondary hazards from volcanoes, and the risks to them. In the survey, the respondents were asked to check all the volcanic hazards and their corresponding risks that they are aware of. Specific hazards and risks were inquired as specialized communication and management strategies are necessary in sudden volcanic eruption mitigation[4].
- Evacuation preparedness: Respondents were asked where they would go, what they would do and how to evacuate during a sudden eruption in Taal.
- Protective gear: Respondents were asked about their hardhat possession and willingness to pay fees to rent hardhats.

Percentage analysis in Microsoft Excel was undertaken in order to gauge the type of volcanic hazard as well as risks which are unknown or irrelevant to the residents and tourists, which evacuation actions are most likely to be performed, and how many are willing to invest in hardhats.

## III. RESULTS AND DISCUSSIONS

### A. Perception on Volcanic Hazards

Tables 2a-b. show the perception of horse guides and tourists on Taal volcano's hazards. Ash and lava are the highly known hazard with 100% and 80% of the respondents answering that they are aware of these hazards. Small rocks and gas pose the lowest percentages of known volcanic hazard with 68.32% and 44.64%. Rocks, gas and debris are both at the bottom half of the known hazards for both horse guides and tourists.

### B. Perception on Risks Corresponding to Hazards

Tables 3a-b. show the perception on risks of Taal volcano's hazards. Both the horse guides and tourists have the lowest rates of perception of risks on rocks. It was observed that people are not aware of the risks that volcanic rocks possess regardless of size most of the known hazards of sudden eruptions were due to ballistic projectiles[7]. It is imperative to further study the necessary strategy for risk communication and management on volcanic rocks or ballistic projectiles[4].

### C. Response on sudden earthquake and explosion in the volcano island

Tables 4a-b. show the responses of horse guides and tourists on a sudden earthquake and explosion scenario in Taal. Most of the horse guides (25%) responded that they would observe first, while most of the tourists (25%) would evacuate to the widest road.

### D. Response on sudden smoke emission in the volcano island

Tables 5a-b. show the responses of horse guides and tourists on a sudden smoke emission scenario in Taal. Most of the horse guides (28.72%) and tourists (39.29%) responded that they would observe first.

### E. Response on sudden smell of sulfur (gas emission)

Tables 6a-b. show the responses of horse guides and tourists on a sudden smell of sulfur (gas emission) scenario in Taal. Most of the horse guides (25.74%) responded that they would run inside the house, while most of the tourists (25%) would cover their noses first.

### F. Response on sudden ashfall

Tables 7a-b. show the responses of horse guides and tourists on a sudden ashfall scenario in Taal. Most of the horse guides (38.61%) and tourists (36%) responded that they would look for a shelter.

### G. Response on sudden rockfall

Tables 8a-b. show the responses of horse guides and tourists on a sudden rockfall scenario in Taal. Similar to the ashfall scenario, most of the horse guides (31.68%) and tourists (39%) responded that they would look for a shelter.

The results revealed that further measures should be performed involving both horse guides and tourists in awareness on a generic and unified response during disasters such as where to proceed during evacuation and how to protect themselves while evacuating.

#### *H. Reasons for living, working in and visiting Taal*

Tables 9a-b. show the responses of horse guides and tourists on their reasons for living, working in and visiting Taal. Most of the horse guides (36.63%) responded that being a horse guide and boatman is their source of income, while most of the tourists (29%) answered beautiful place/sight/nature.

#### *I. Possession of and willingness to purchase insurance*

Tables 10a-b. show the responses of horse guides and tourists on their possession of and willingness to purchase insurance as a precautionary measure in case of any accident or disaster. Most of the horse guides (45.54%) responded that they do not own an insurance. In contrast, most of the tourists (48%) answered that they are willing to purchase an insurance.

#### *J. Possession of and willingness to hike with hardhat*

Tables 11a-b. show the responses of horse guides and tourists on their possession of and willingness to purchase a hardhat as a precautionary measure in case of any accident or disaster. Most of the horse guides (56.44%) responded that they do not own a hardhat. In contrast, most of the tourists (68%) answered that they are willing to hike with a hardhat.

#### *K. Willingness of tourists to rent or purchase hardhat and price*

Tables 12-13. show the responses of tourists on their willingness to rent or purchase a hardhat as a precautionary measure in case of any accident or disaster, and how much they would be willing to pay for the rental fee or price of hardhat. Most of the tourists (84.21%) responded that they would be willing to rent a hardhat. Also, 76% of the tourists would rent a hardhat for PhP500.00.

#### *L. Price of entrance fee at the Taal volcano island*

Tables 14-15 show the responses of tourists on their insight on the price of entrance fee at Taal's volcano island, and how much they are willing to pay for the entrance fee. Most of the tourists (66%) responded that the entrance fee's price is just right. Also, most of the tourists (41%) would pay the current price of PhP50.00 for the entrance fee, yet a close 36% would be willing to pay PhP100.00.

The results revealed that the horse guides still lack the utmost preparation during volcanic disasters especially on sudden events. They are still uncoordinated on the evacuation and safety protocols and do not possess the necessary emergency equipment. However, they would be willing to have equipment if there's enough financial resource or support from authorities.

For the tourists, they are also unaware of the hazards and evacuation procedures yet they are willing to invest for safety purposes such as protective equipment and entrance fee in Taal. The renting and charging of hardhat and entrance fees can be good measures to promote not only disaster preparedness but also for income generation for the local community.

## IV. CONCLUSION

Awareness on volcanic hazards and risks and the necessary response and equipment are integral in disaster preparation on sudden eruptions. While the mechanism and prediction of the unrest and events are still being studied improved, this study hopes to provide insights on further countermeasures necessary to mitigate sudden volcanic eruptions in the future.

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Volcanic hazard	Total (number of people)*	Percentage (%)
Ash	101	100
Smoke	99	98.02
Evacuation accidents	91	90.10
Lava	90	89.11
Earthquake	88	87.13
Medium rocks	77	76.24
Gas	77	76.23
Debris	75	74.26
Big rocks	71	70.30
Small rocks	69	68.32

\*n = 101

Table 2a:- Volcano Hazards Perception Of Tour Guides

Volcanic hazard	Total (number of people)*	Percentage (%)
Lava	45	80
Ash	44	78.58
Evacuation accidents	39	69.64
Earthquake	39	69.94
Smoke	39	69.64
Small rocks	28	50
Debris	27	48.21
Big rocks	25	44.64
Large rocks	25	44.64
Gas	25	44.64

\*n = 56

Table 2b:- Volcano Hazards Perception of Tourists

<b>Volcanic hazard and the corresponding risk with highest response</b>	<b>Responses (no. of people)</b>	<b>Percentage (%) (respondents of risk /respondents of hazard)</b>
Ash – Intrusion or infection of eyes and nose	77	76.24
Smoke – Difficulty in breathing	65	65.66
Gas – Poison/Toxicity	55	71.43
Debris – Collapse of ceiling	39	52
Small rocks – Head injury/lump	29	42
Medium rocks – Head injury/lump	40	52
Large rocks – Head injury/lump	28	39.44
Earthquake – Damage to houses and bldgs.	41	47
Lava – Skin burns	45	50
Evacuation accidents – Stampede	77	84.62

Table 3a:- Volcano Risk Perception Of Horse Guides

<b>Volcanic hazard and the corresponding risk with highest response</b>	<b>Responses (no. of people)</b>	<b>Percentage (%) (respondents of risk /respondents of hazard)</b>
Ash – Difficulty in breathing	31	70.45
Smoke – Difficulty in breathing, eyes & lung infection	30	77
Gas – Poison/Toxicity	21	84
Evacuation accidents – Stampede	30	76
Lava – Skin burns	24	53.33
Earthquake – Damage to houses and bldgs.	29	74
Medium rocks – Head injury/lump	16	64
Debris – Collapse of ceiling		
Large rocks – Head injury/lump	19	76
Small rocks – Head injury/lump	12	43

Table 3b:- Volcano Risk Perception of Tourists

Response	Total (number of people)*	Percentage (%)
a. Run to the shore	6	5.94
b. Run inside the house	1	0.99
c. Evacuate to the nearest road	22	21.78
d. Evacuate to the widest road	23	22.77
e. Evacuate where others will evacuate	11	10.89
f. Look for a shelter	6	5.94
g. Will cover self	5	4.95
<b>h. Will observe first</b>	<b>26</b>	<b>25.74</b>
i. No answer	1	0.99

\*n=101

Table 4a:- Response of Horse Guides On Sudden Earthquake and Explosion

Response	Total (number of people)*	Percentage (%)
a. Run to the shore	1	1.76
b. Run inside the house	0	0
c. Evacuate to the nearest road	10	17
<b>d. Evacuate to the widest road</b>	<b>14</b>	<b>25</b>
e. Evacuate where others will evacuate	8	14
f. Look for a shelter	6	11
g. Will cover self	6	11
h. Will observe first	8	14
i. No answer	3	5

\*n=56

Table 4b:- Response of Tourists on Sudden Earthquake and Explosion

Response	Total (number of people)*	Percentage (%)
a. Run to the shore	7	6.93
b. Run inside the house	6	5.94
c. Evacuate to the nearest road	19	18.81
d. Evacuate to the widest road	5	4.95
e. Evacuate where others will evacuate	16	15.84
f. Look for a shelter	5	4.95
g. Will cover self	10	9.90
<b>h. Will observe first</b>	<b>29</b>	<b>28.72</b>
i. No answer	4	3.96

\*n=101

Table 5a:- Response of Horse Guides On Sudden Smoke Emission

Response	Total (number of people)*	Percentage (%)
a. Run to the shore	2	2
b. Run inside the house	3	3
c. Evacuate to the nearest road	9	16.07
d. Evacuate to the widest road	9	16.07
e. Evacuate where others will evacuate	1	2
f. Look for a shelter	5	9
g. Will cover self	1	2
<b>h. Will observe first</b>	<b>22</b>	<b>39.29</b>
i. No answer	4	7.14

\*n=56

Table 5b:- Response of Tourists on Sudden Smoke Emission

Response	Total (number of people)*	Percentage (%)
a. Run to the shore	13	12.87
<b>b. Run inside the house</b>	<b>26</b>	<b>25.74</b>
c. Evacuate to the nearest road	5	4.95
d. Evacuate to the widest road	2	1.98
e. Evacuate where others will evacuate	3	2.97
f. Look for a shelter	2	1.98
g. Will cover nose first	24	23.76
h. Will observe first	23	22.77
i. No answer	3	2.97

\*n=101

Table 6a:- Response Of Horse Guides On Sudden Smell Of Sulfur

Response	Total (number of people)*	Percentage (%)
a. Run to the shore	2	2
b. Run inside the house	2	2
c. Evacuate to the nearest road	4	4
d. Evacuate to the widest road	5	4.95
e. Evacuate where others will evacuate	3	5.35
f. Look for a shelter	2	4
<b>g. Will cover nose first</b>	<b>18</b>	<b>32.14</b>
h. Will observe first	15	27
i. No answer	5	9

\*n=56

Table 6b:- Response Of Tourists On Sudden Smell Of Sulfur

Response	Total (number of people)*	Percentage (%)
a. Run to the shore	9	8.91
b. Run inside the house	14	13.86
c. Evacuate to the nearest road	11	10.89
d. Evacuate to the widest road	3	2.97
e. Evacuate where others will evacuate	6	5.94
<b>f. Look for a shelter</b>	<b>39</b>	<b>38.61</b>
g. Will cover self	7	6.93
h. Will observe first	9	8.91
i. No answer	3	2.97

\*n=101

Table 7a:- Response Of Horse Guides On Sudden Ashfall

Response	Total (number of people)*	Percentage (%)
a. Run to the shore	2	4
b. Run inside the house	2	4
c. Evacuate to the nearest road	8	15
d. Evacuate to the widest road	2	4
e. Evacuate where others will evacuate	6	11
<b>f. Look for a shelter</b>	<b>20</b>	<b>36</b>
g. Will cover self	5	9
h. Will observe first	8	14
i. No answer	3	5

\*n=56

Table 7b:- Response of Tourists on Sudden Ashfall



Response	Total (number of people)*	Percentage (%)
a. Run to the shore	8	7.92
b. Run inside the house	7	6.93
c. Evacuate to the nearest road	5	4.95
d. Evacuate to the widest road	16	15.84
e. Evacuate where others will evacuate	15	14.85
<b>f. Look for a shelter</b>	<b>32</b>	<b>31.68</b>
g. Will cover self	4	3.96
h. Will observe first	11	10.89
i. No answer	3	2.97

\*n=101

Table 8a:- Response Of Horse Guides On Sudden Rockfall

Response	Total (number of people)*	Percentage (%)
a. Run to the shore	3	3
b. Run inside the house	2	2
c. Evacuate to the nearest road	5	5
d. Evacuate to the widest road	7	13
e. Evacuate where others will evacuate	6	11
<b>f. Look for a shelter</b>	<b>22</b>	<b>39</b>
g. Will cover self	4	7
h. Will observe first	4	7
i. No answer	3	5

\*n=56

Table 8b:- Response Of Tourists On Sudden Rockfall

Reason	Total (number of people)*	Percentage (%)
a. Beautiful place/sight/nature	9	8.9
b. Source of income	37	36.63
c. Happiness	0	0
d. Others (already born there, family, etc.)	6	5.94
e. No answer	50	49.50

\*n=101

Table 9a:- Reasons of Horse Guides For Living And / Or Working in Taal

Reason	Total (number of people)*	Percentage (%)
<b>a. Beautiful place/sight/nature</b>	<b>16</b>	<b>29</b>
b. Adventure, curiosity and experience	6	11
c. Just want it and willing	5	9
d. Invited by a local	2	4
e. No answer	27	48

\*n=56

Table 9b:- Reasons Of Tourists For Visiting Taal

Answer	Total (number of people)*	Percentage (%)
a. Yes (Social security/pension)	3	2.97
<b>b. No</b>	<b>46</b>	<b>45.54</b>
c. No answer	52	51.49

\*n=101

Table 10a:- Horse Guides' Insurance Possession

Answer	Total (number of people)*	Percentage (%)
<b>a. Yes (Social security/pension)</b>	<b>27</b>	<b>48</b>
b. No	18	32
c. No answer	11	20

\*n=56

Table 10b:- Willingness Of Tourists To Purchase Insurance

Answer	Total (number of people)*	Percentage (%)
a. Yes	1	0.99
<b>b. None</b>	<b>57</b>	<b>56.44</b>
c. No answer	43	42.57

\*n=101

Table 11a:- Horse Guides' Hardhat/Helmet Possession

Answer	Total (number of people)*	Percentage (%)
<b>a. Yes</b>	<b>38</b>	<b>68</b>
b. None	6	11
c. No answer	12	21

\*n=56

Table 11b:- Willingness Of Tourists To Hike With Hardhat

Answer	Total (number of people)*	Percentage (%)
a. Buy	4	10.53
<b>b. Rent</b>	<b>32</b>	<b>84.21</b>
c. No answer	2	5.3

\*n=56

Table 12:- Responses Of Tourists On Willingness To Rent Or Purchase A Hardhat

Price	Total (number of people)*	Percentage (%)
<b>a. PhP500.00</b>	<b>29</b>	<b>76</b>
b. PhP1000.00	1	2.63
c. PhP2000.00	0	0
d. Lower than PhP500.00	8	21.05

\*n=56

Table 13:- Responses of Tourists on the Price They Would Be Willing To Pay For Rental of Hardhats

Price (PhP50.00)	Total (number of people)*	Percentage (%)
a. Expensive	7	12.5
b. Cheap	6	11
<b>c. Just right</b>	<b>37</b>	<b>66</b>
d. No answer	6	11

Table 14:- Insight On The Current Price Of Entrance Fee At Taal Volcano Island

<b>Price</b>	<b>Total (number of people)*</b>	<b>Percentage (%)</b>
<b>a. PhP50.00</b>	<b>23</b>	<b>41</b>
b. PhP100.00	20	36
c. PhP150.00	10	18
d. No answer	3	5

Table 15:- Responses Of Tourists On The Price They Would Be Willing To Pay For Entrance Fee