AN AXE OVER OUR HEADS! THE DISASTER RISK EXPOSURE OF COMMUNITIES ALONG THE TAPIAN PIT OF MARCOPPER MINING CORPORATION: BASIS FOR DISASTER PREPAREDNESS ENHANCEMENT PROGRAM

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ABSTRACT: *The remnants of former mining operations in Marinduque are exposing the communities to continuous exposure to risk, thus this study focuses on the disaster risk exposure (DRE) of the three communities, such as: Hinapulan, Makulapnit and San Antonio, which are located in the periphery of Marcopper's Tapian Pit. This study measured quantitatively the disaster risk exposure indices (DREI) of the communities in terms of hydro-meteorological, geophysical, food and agricultural, household wastes, human health and socio-economic dimensions as observed and experienced of the households. It employed a tested instrument with 24 attributes referring to the cited dimensions using a 5-point scale ranging from highly exposed to risk to not expose to risk. Results of the study revealed the majority of the 24 measured attributes have indices of "exposed to risk". Attributes for hydro-meteorological and geophysical dimensions, such as extreme rainfall, frequency, and severity of typhoons, erosion, and siltation of rivers and streams, contamination of rivers and proneness to destruction due to topography are main causes for the communities to be "highly exposed to risk". The over-all mean indices for the communities are as follows: 4.12 for San Antonio, 4.01 for Hinapulan and 3.85 for Makulapnit. Furthermore, results of this study can be used as a basis in formulating a concrete Disaster Preparedness Program that will capacitate the local villagers and mobilize the local government officials, academe and the civil societies to do campaign and information dissemination activities, readying the community people to the possible effects of climate change.*

Keywords: awareness, crisis management, disaster risk exposure, preparedness

INTRODUCTION

For the climate change science and disaster risk reduction and mitigation parlance, hazard has been defined as a condition, a situation, an event or a process that can cause harm or damage. Hazard can be natural or human-induced physical events that can have adverse effects on vulnerable and exposed elements [1,2,3]. This will become a risk if there is exposure to possible harm or damage.

Risk, on the other hand, is the possibility or the probability that a hazard can cause damage to properties, life and environment [4] while the **e**xposure is the proximity of an area or group to elements or dimensions of hazardous events that may occur [5,6,7].

In relation to the above definition, this study focused on the case of Marcopper Mining Corporation in Marinduque. To many of the people, based from their experiences considered mining is an unsustainable process that involves the destruction of the whole milieu of the environment which ends up to the lives of the people in the long run. Once mining was done, like the case of Marcopper Mining Corporation (hereafter known as Marcopper), the remnants of the operation remain for a generation to generation before nature heals it. The mining fields left behind, the eroding mountains, the persistent heavy metals, and scattered acid mine drainage, the acidic brew in mine-made lakes and ponds and the chemical-laden rivers and streams remain a hazard to the lives of the people nearby. These hazards, coupled with extreme and severe changes in the environment as brought by climate change, remain an ax over the heads of the people living nearby; exposing them to the possibility of great damage anytime.

As such, this study looks on the Disaster Risk Exposure Indices (DREI) of the three communities along the periphery of the mining operations of Marcopper Mining Corporation, such as barangays Hinapulan, Makulapnit and San Antonio.

Marcopper Mining Corporation: A Retrospect

To date, it is 22 years now when Marcopper stopped its operation in Marinduque. At first, it started extensive geological mapping and drilling in the province in 1956 [8]. It operated mining in the province for almost 30 years that provided more than 1,000 employment and $30 million a year for local goods and services, as well as electricity for the province [9,10]. But, still, the island province remains among the poorest provinces in the country. The Philippine government supports multinational corporations and actively seeks to bring their investments, like mining, into the country [9,11].

During the start of its operation in 1969, the company was under Placer Dome, a Canadian company, co-owned (39.9%) and managed the corporation. The Mt. Tapian, a more than 800 meters above sea level (masl) mountain near the northern middle part of the province was mined for copper ore in 1969 to 1990, using an open pit mining [10]. The operation created a crater-like bluish lake facing Hinapulan, the closest barangay and the remaining unstable, steep slopey side of the mountain is facing barangays Makulapnit and San Antonio. The tons and tons of excavated portions of the mountain were disposed into wastelands along the vicinity until 1972. Then in 1975, the disposed of wastes, especially the mine tailings were dumped into the Calancan Bay at the rate of 2.5 tons per second [12].

It was estimated that a total of no less than 84 million metric tons of mine tailings were discharged into this shallow bay between 1975 and 1988, forming an 8km causeway seaward [13] near the Hakupan and Banot islands in barangay Botilao, Sta. Cruz. As a consequence of the long fight of the people against the continued dumping of mine tailings into Calancan Bay, it was agreed that the lake-like Tapian Pit would be used as dumping site of mine wastes in a temporary basis. This disposal method was not discussed in the Environmental Impact Assessment with the DENR [14].

When the ore body of the Tapian Pit was depleted, the mining operation was transferred to San Antonio ore body for another 20 years. Since the San Antonio ore is of low grade containing only 0.44% copper, tons and tons of rocks were removed in the form of tailings and these were dumped into the copper depleted pit. In spite of the unconventional use of the Tapian Pit as a containment system, no environmental risk assessment and management were done.

Since 1993, it was estimated that about 20 million cubic meters of tailings have been impounded in the Taipan Pit, which is 300 meters deep and had an estimated capacity of approximately 69 million cubic meters. With the increasing structural damage brought by typhoon, heavy rains and massive erosion as triggered by climate change, in 1995 the residents of Hinapulan and nearby barangays reported their fear that the pit would burst into destruction [8].

On 24 March 1996, the fear of the people with this hazardous condition happened, because of about 2 to 3 million tons of mine waste leaked into the 26-kilometer long Boac River. The concealed plug that sealed the Tapian pit tunnel to the Boac River burst maybe due to the pressure from the Tapian pit that contained around 23 million metric tons of mine waste [15].

As by the assessment, the immediate effects were disastrous [16]. The Makulapnit and Boac River system has been so significantly covered with mine wastes. The aquatic life, productivity and beneficial use of the rivers for domestic and agricultural purposes were totally damaged as a result of the physical process of sedimentation. There were also an increased health and safety risk due to immersion and flooding as a result of the very large volume and physical properties of the mine tailings that were carried downstream during the wet season.

Despite these findings, Marcopper held on to the claim that the tailings were non-toxic. Residents also complained of skin irritations and respiratory problems, which could have been caused by the poisonous vapors emitted from the tailings [15,17].

Now that the mining operation was totally stopped in the province, the remnants of mining are never monitored regularly and anybody, even government officials are not allowed to enter the said site. It is feared by the people, especially during typhoon seasons something disastrous would happen in the province. The damaged dams can overflow due to earthquakes and heavy storms. Landslides from the denuded mountains and mine wastes that include toxic waste are also being feared that may be affected by heavy rains.

The 1996 Marcopper tragedy in Marinduque brought national and international mileage in the news and among researchers. Literature reviews revealed some published studies conducted after the pandemonium, especially the study on the socioeconomic effects of mining to the communities [18], the corporate and public governance on mining [19], the presence of heavy metals in Boac and Mogpog rivers and the Calancan Bay and their effects to river and marine organisms [20, 21, 22, 23, 24] and health of the community people affected by mine tailing [25]. But, there is a scarcity of concrete studies on the disaster risk exposure of the nearby communities that would be brought by the neglected and unrehabilitated remnants of Marcopper in the province, which would be triggered more by the effects of climate change. As the residents of nearby communities said, “Marcopper has left an ax over our heads that anytime will fall on us!"

To regularly monitor these mining hazards in the nearby communities and in relation to climate change, this study looked on the Disaster Risk Exposure Indices (DREI) of Hinapulan, Makulapnit and San Antonio communities, all located along the former mine site and Tapian Pit.

The dimensions measured in this study were the following and based on the studies made by other researchers as indicated:

1. Hydro-meteorological Dimensions (HMD) based from the research works on landslide and rain infiltration [26], flood susceptibility of mountainous basin [27], typhoons and climate change in the Philippines [28] and drought prediction [29].
2. Geophysical Dimensions (GPD) scoped from the study on the environmental risks of mine tailings pond [30,31].
3. Food and Agricultural Dimensions (FAD) based from the works on mining and food security [32].
4. Human Health Dimensions (HHD) scoped from the works on health risks and natural disasters [33].
5. Household Wastes Dimensions (HWD) based on the relationship between health risk, household wastes and climate change [34].
6. Socioeconomic Dimensions (SED) based on the works on economic risks and resilience in the Philippines [35] and on mining and livelihood [32].

RESEARCH METHODOLOGY

Research Design. The study is a descriptive quantitative and qualitative research that looked on the observations and experiences of the community households regarding their level of disaster exposure to the remnants of mining and the effects of climate change to their lives in the study area. The study used a prepared questionnaire as the prime instrument that measured the households’ level of exposure to disaster in terms of the following dimensions:

1. Hydro-meteorological dimensions (HMD) with 5 sub-dimensions (e.g. rainfall, typhoon visit and intensity, temperature rise, drought and scarcity of water supply)
2. Geophysical Dimensions (GPD) with 5 sub-dimensions (e.g. landslide, earthquake, proneness to isolation, flooding and contamination of land and water)
3. Food and Agricultural Dimensions (FAD) with 5 sub-dimensions (e.g. soil acidity, crop infestation, dependence on agrichemicals, decreasing fish catch and animal diseases)
4. Household Wastes Dimensions (HWD) with 3 sub-dimensions (e.g. volume of domestic wastes, the volume of nonbiodegradable wastes, unsustainable disposal of wastes)
5. Human Health Dimensions (HHD) with 3 sub-dimensions (e.g. increasing number of PWDs and vulnerable individuals, malnutrition and human diseases)
6. Socioeconomic Dimensions (SED) with 3 sub-dimensions (e.g. poverty, sources of livelihoods, income, and credits)

These 24 sub-dimensions or attributes were rated by the household members at the scale of 5, where 5 means highly exposed to risk (HER); 4, exposed to risk (ER); 3, moderately exposed to risk (MER); 2, rarely exposed to risk (RER) and 1, not exposed to risk (NER)

The Study Area. The study considered the three nearby communities that are within the closest periphery of Marcopper Tapian Pit, such as Hinapulan, Boac, located in the western side of the pit; San Antonio, Sta. Cruz, located

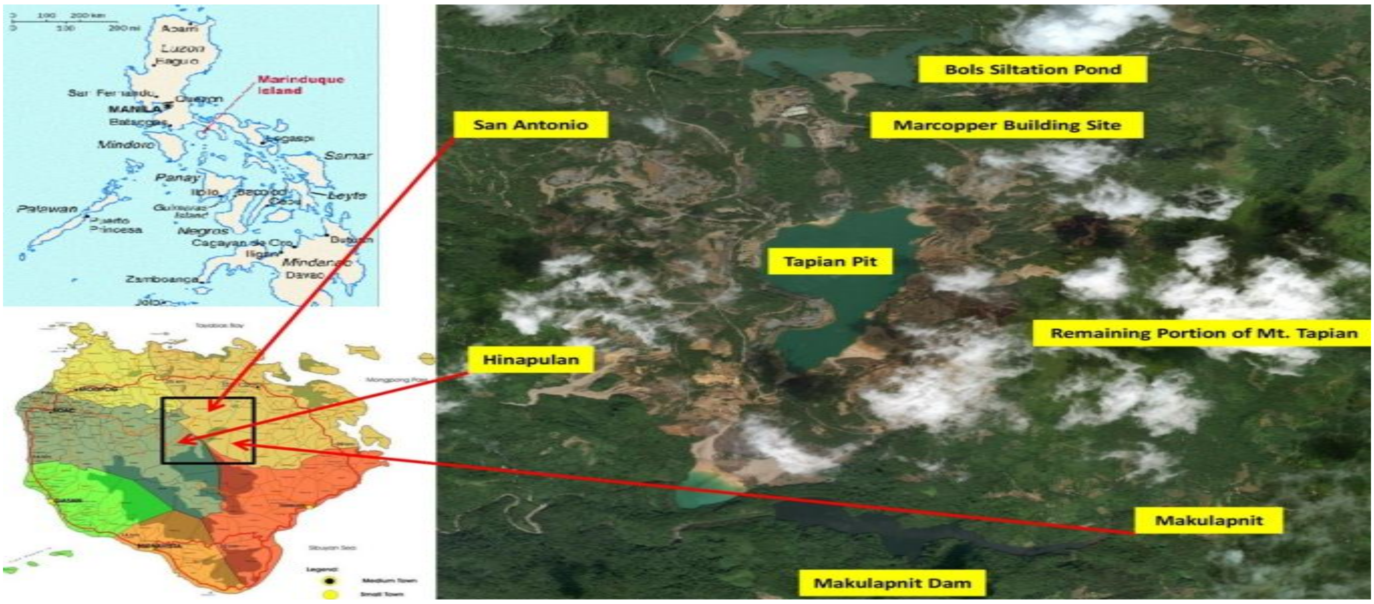

Fig. 1. The location of the barangays Hinapulan, Makulapnit and San Antonio in relation to the location of Marcopper Mine Site

in the northern side of the pit and near the Bols Dam, which was the former dumping area of mine water wastes and Makulapnit, Sta Cruz, located in the southeastern side of the pit where the Makulapnit Dam is located. These barangays are in the forefronts when a disaster occurs within the mine area (Fig. 1).

Population, Sample and Residency. As shown in Table 1, the analysis of data was based on 140 households with mean residency in the area of 30.96 years, thus they have full knowledge and experiences about the effects of mining in their communities as well as their relationship to climate change.

Table 1. Number of households interviewed households and mean residency in the barangay (Philippine Statistics Authority Office-Marinduque 2017).

Barangays	No. households (HHs)	No. interviewed HHs	Percent (%)	Mean Residency (years)
Hinapulan, Boac	158	50	31.65	33.42
Makulapnit, Sta. Cruz	101	31	30.69	30.12
San Antonio, Sta. Cruz	205	59	28.78	29.35
Total	464	140	30.17	30.96

Validation for Reliability of the Instrument. The developed instrument was pilot-tested to 15 respondents, five each from the community people nearby the area, teachers and government, officials who have enough knowledge and experiences about the topic. A Cronbach's alpha model was used for measuring the internal consistency of the questionnaire, which is “an indicator of to what extent all the items in a scale can successfully measure any dimension” [36]. The computed Cronbach Alpha value for each dimension ranges from 0.70 to 0.86, which considered the instrument acceptable for reliability in every social research.

Treatment of Data and Analysis. The collected data were recorded and organized in the Microsoft Excel using SPSS and afterward, an appropriate statistical tool was used for the computation of the means and the overall means of the six dimensions measured for each barangay. The mean results were interpreted objectively based on findings and analysis using the following ranges; Table 2:

Table 2

Scale Range	Descriptor
4.50 – 5.00	highly exposed to risk (HER)
3.50 – 4.49	exposed to risk (ER)
2.50 – 3.49	moderately exposed to risk (MER)
1.50 – 2.49	rarely exposed to risk (RER)
1.00 – 1.49	Not exposed to risk (NER)

Analysis of variance (ANOVA) and Duncan multiple range test (DMRT) at 5% level of significance was used to find out the differences of the three communities with regard to the measured six dimensions.

For further interpretation of findings, side interviews using qualitative methods were done and the findings were coupled with document analysis from government reports and other published and unpublished research work, like a thesis.

RESULTS AND DISCUSSION

1.0 Hydro-meteorological Dimension (HMD)

Under the hydro-meteorological dimensions (Fig. 2), highest ratings were given by the households on typhoon frequency visit and intensity of effects, 4.72 for Hinapulan, 4.70 for San Antonio and 4.69 for Makulapnit with no significant difference in what has been observed and experienced by the households in the three communities at 5% level of significance. This indicated that the households fear typhoons, thus they considered that they are “highly exposed to typhoon risks”, which can be linked to the last typhoon that visited the province in 2015. Based on the report of the Provincial Disaster Risk Reduction and Mitigation Management Office, 80% of the households in the said barangays were destroyed by Typhoon Nina. But, a lesser effect of destruction was observed in Makulapnit, because the barangay was covered by the forested southern flank of Mt. Tapian.

Highest ratings were also given by the households on extreme precipitation, 4.50 (highly exposed to risk) for Hinapulan. This may be related to the closeness of the community to the dumped mine wastes that remain barren and steep, which can erode anytime to the households during heavy precipitation. For San Antonio and Makulapnit, the indices given were 4.49 (exposed to risk) and 4.48 (exposed to risk) respectively. Statistically, these indices are found not significantly different for each barangay at a 5% level of significance. Generally, high rainfall is observed during typhoon season, thus these values are related to the frequency of typhoon visits and its intensity.

Majority of the measured attributes for hydro-meteorological dimensions were within the 3.50 to 4.49 range, like extreme heat and drought and scarcity of domestic water supply, which are related to one another and given with “exposed to risk” descriptor. Lowest indices were given to extreme drought (3.93, exposed to risk) and temperature rise (3.57, exposed to risk) by the households in Makulapnit. The people may be not so affected by these attributes, though still rated “exposed to risk”, because Makulapnit is surrounded by a forest and has the Makulapnit Dam, with waters not affected by mine wastes at present.

The computed general mean of all the five attributes for hydro-meteorological dimension showed that Hinapulan has indices of 4.44 (exposed to risk), followed by San Antonio, 4.41 (exposed to risk) and Makulapnit, 4.18 (exposed to risk). Statistically, these values are significantly different at 5% level of significance, where Hinapulan and San Antonio have indices that are not significantly different, as they are both located at the eastern side of the Tapian Pit and the eroded side of Mt. Tapian. The index for Makulapnit is significantly different, which may be due to its location. It is nestled at the forested southwestern side of Mt. Tapian.

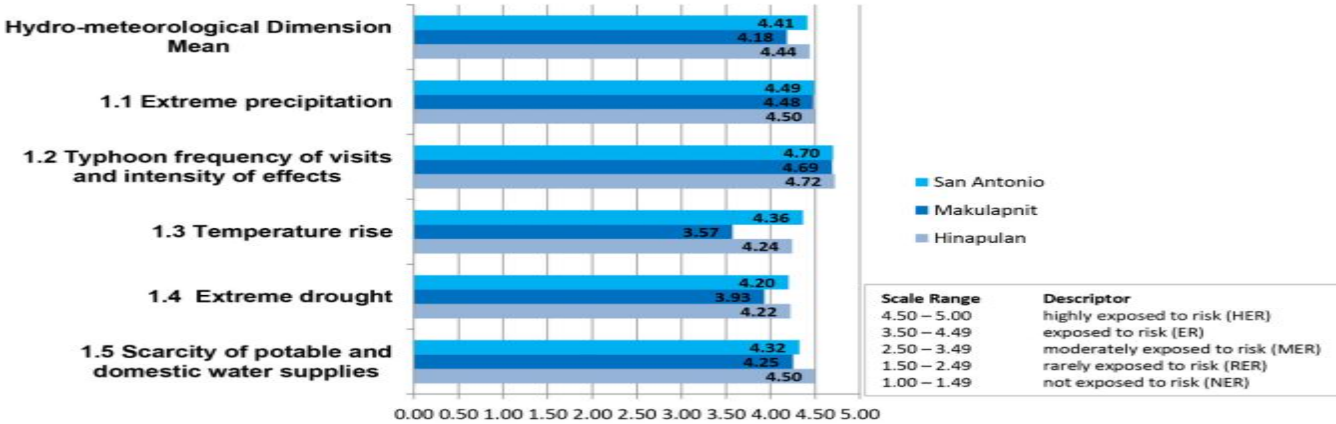

Fig. 2. Hydro-meteorological indices of barangay Hinapulan, Makulapnit, and San Antonio.

2.0 Geophysical Dimension (GPD)

In Fig. 3, the indices and attributes for the geo-physical dimension are presented. Of all the attributes indicated, highest ratings were given by the households in Hinapulan for erosion and siltation of rivers and streams (4.76, highly exposed to risk) and proneness to destruction due to topography (4.76, highly exposed to risk).

These are followed by indices for Makulapnit, also under erosion and siltation of rivers and streams (4.71, highly exposed to risk) and increasing contamination of rivers and streams (4.71 highly exposed to risk). The residents experienced it during the Typhoon Nina where parts of the forested area in the southwestern side of Mt. Tapian eroded toward the Makulapnit Dam, thus they believed that mine wastes might flow in their community. But a study on the level of copper and other heavy metals in the dam was far below the permissible limit [37].

San Antonio on the other hand also showed indices that are described as "highly exposed to risk", such as 4.69 for erosion and siltation of rivers and streams, 4.68 for proneness to destruction due to topography and 4.53 for increasing contamination of rivers and streams. These observations can be related to the closeness of the community to Bols Siltation Pond and Marcopper Operation Area where during rainy days parts of the abandoned mine wastes flow erode to the communities. an index of 3.98 (exposed to risk). Location is considered as the main factor because San Antonio is facing the eroded part of Mt. Tapian and also the site of the Bols Siltation Pond of Marcopper. Makulapnit followed because of the households' fear of isolation when a disaster occurs. Its road system is connected to Marcopper where restriction to commuters is imposed by the security guards. Though Hinapulan is located near the Tapian Pit and the eroded portion of the dumped mine wastes, it has improved road system connected to Boac and Mogpog, where outside help can easily come.

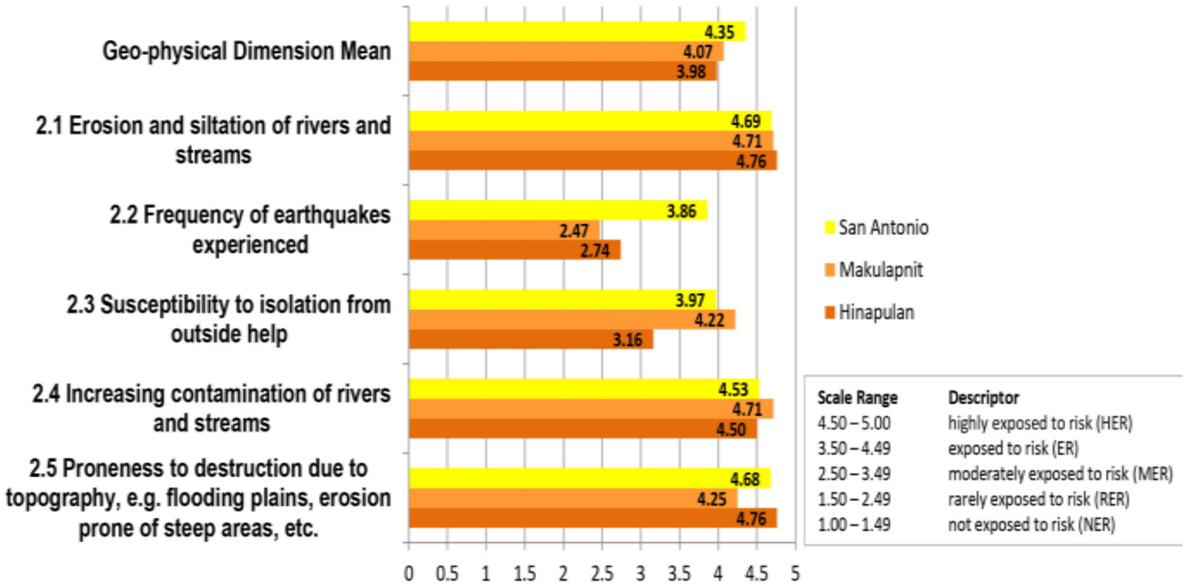

Fig. 3. Geo-physical indices of barangays Hinapulan, Makulapnit and San Antonio.

Lowest indices were given to frequency of earthquakes, 2.47 (rarely exposed to risk) for Makulapnit, 2.74 (moderately exposed to risk) for Hinapulan and 3.16 (moderately exposed to risk) on susceptibility to isolation for Hinapulan. This may be related to the low seismicity level of the province as this is not generally visited by strong earthquakes [38].

Statistically, the computed general mean of all the five attributes for geo-physical dimension showed significant differences at the 5% level. San Antonio has the highest mean index at 4.35 (exposed to risk), followed by Makulapnit (4.07, exposed to risk) and last, Hinapulan with

3.0 Food and Agricultural Dimension (FAD)

In Fig. 4, the five attributes for Food and Agricultural Dimension showed highest readings for increasing soil acidity for San Antonio (4.55, highly exposed to risk) and Hinapulan (4.50, highly exposed to risk). This is so, because during rainy days and typhoon season mine waste seepages could be observed flowing to the agricultural lands, especially those located at the lower part of the barangay. This can be confirmed in the study made on the levels of copper in the root crops harvested within the area [39].

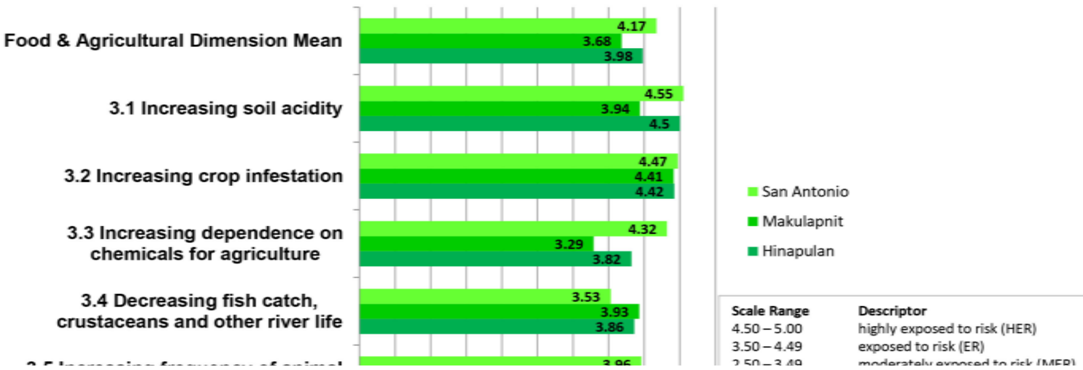

Fig. 4. Food and agricultural indices of barangays Hinapulan, Makulapnit and San Antonio.

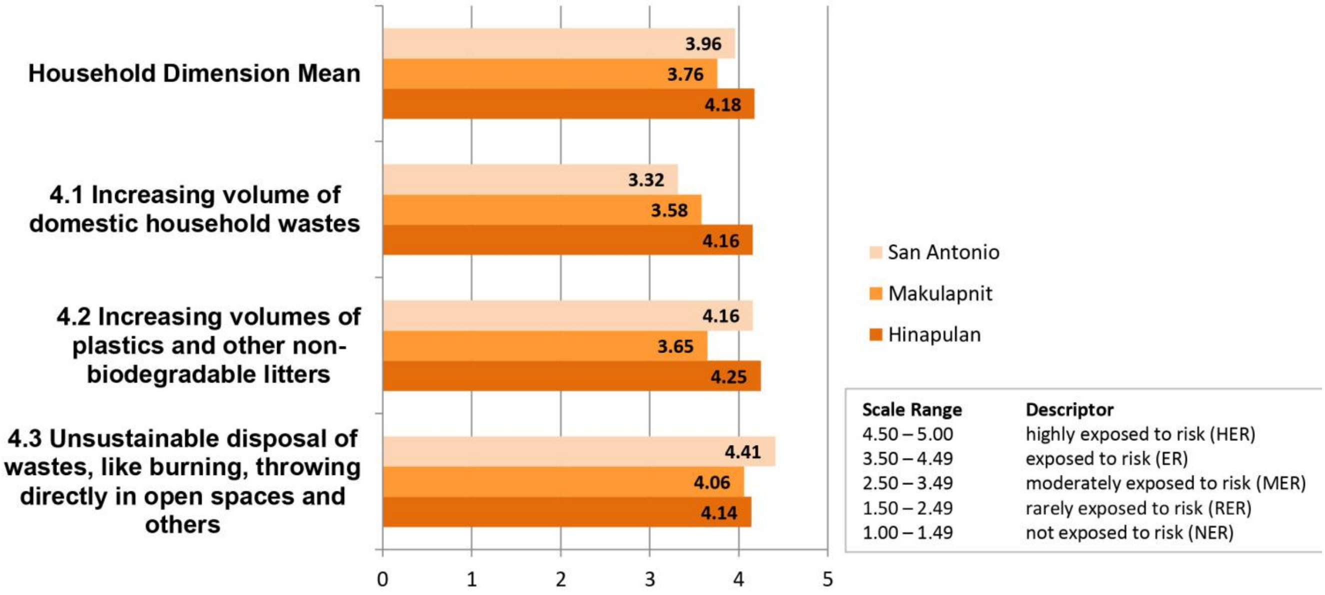

Fig. 5. Household wastes indices of barangays Hinapulan, Makulapnit and San Antonio.

This is followed by increasing crop infestation, 4.47 (exposed to risk) for San Antonio, 4.42 (exposed to risk) for Hinapulan and 4.41 (exposed to risk) for Makulapnit. The study revealed that crop infestation is triggered by climate change during extreme weather conditions.

Makulapnit and Hinapulan are "moderately exposed to risk" with regard to the use of agrichemicals, 4.32 and 3.82 respectively. This may be related to the high level of acidity of the soil in the said barangays as affected by mine wastes.

Fish catch and crustaceans in the three barangays are all indicated as "exposed to risk", due to mining contamination of rivers and streams as reflected in the findings of David [22].

Lowest indices are recorded for Makulapnit, for animal diseases and infestation (2.81, moderately exposed to risk) and dependence on agrichemicals (3.29, moderately exposed to risk).

The computed general mean of all the five attributes for food and agricultural dimension showed that the households are "exposed to risk". San Antonio has an index of 4.17, followed by Hinapulan, 3.98 and Makulapnit, 3.68. Statistically, these indices are significantly different at 5% level of significance. It can be said that Makulapnit has lower risk exposure on dimensions related to food and agriculture.

4.0 Household Wastes Dimension (HWD)

Fig. 5 shows the household wastes indices of the three barangays that can further trigger possible risk exposure of the households. The highest recorded index was that of San Antonio (4.41, exposed to risk) for unsustainable disposal of wastes that includes burning, throwing to open spaces, etc. It is followed by Hinapulan (4.21, exposed to risk) for the increasing volume of plastics and other non-biodegradable wastes, Makulapnit (4.16, exposed to risk) for the increasing volume of domestic wastes and San Antonio again (4.16, exposed to risk) for the increasing volume of plastic wastes and other non-biodegradable wastes.

When these wastes are coupled with mine wastes and debris, more negative impact can be brought to the health of the population, because there are household wastes that can be dissolved in the acidic brew of mine wastes, making them more bioavailable to the environment and to the food of the people.

The general mean of the three attributes that comprised household waste dimension are all categorized as "exposed to risk". The highest reading was 4.18 for Hinapulan, followed by 3.96 for San Antonio and 3.76 for Makulapnit.

Majority of the computed indices are within the "exposed to risk" attributes, which means the households are not practicing solid wastes management.

5.0 Human Health Dimension (HHD)

For human health dimension with three attributes (Fig. 6), the highest index was 4.24 (exposed to risk) recorded in San Antonio. This has been supported by the report of the Barangay Health Worker that respiratory infections and skin diseases are the common recorded illnesses of the people [40]. In the study made with USA Environmental Protection Agency, levels of heavy metals like copper, zinc, lead, and cadmium were at unacceptable levels in soil and dust that generally inhaled by the people [7].

This is followed by the increasing incidence of malnutrition among children, 4.04 for Hinapulan and 4.00 each for San Antonio and Makulapnit with "exposed to risk" descriptor. This was supported by the findings of the assigned Barangay Health Workers and that of the Provincial Social Workers.

Lowest indices were recorded under the number of PWDs, vulnerable children women and senior citizens, 2.71 for Makulapnit and 3.12 for Hinapulan, all categorized as "moderately exposed to risk".

Majority of the general mean of the three attributes that comprised human health dimension are all categorized as "exposed to risk". The highest reading was 3.93 for San Antonio, followed by 3.57 for Hinapulan and 3.45, "moderately exposed to risk for Makulapnit. Statistically, there significant differences among these values at 5% level, wherein Makulapnit can be said to be at good condition, which can be related to its forested area that protects it from the soil, water, and air contamination.

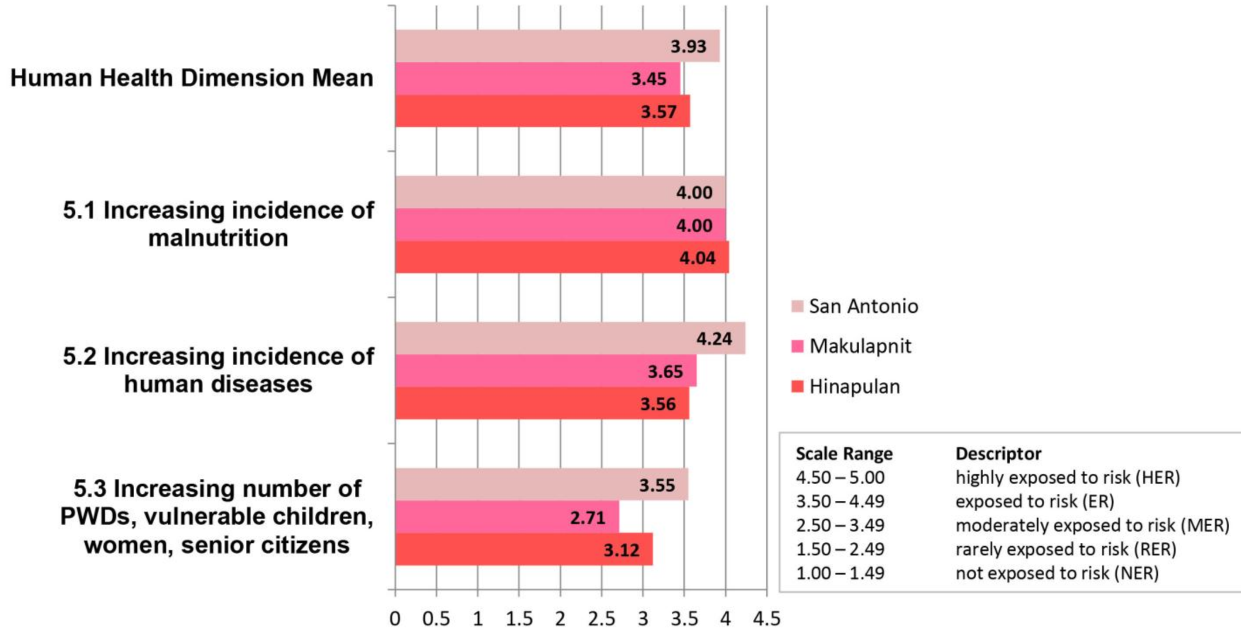

Fig. 6. Human health indices of barangays Hinapulan, Makulapnit and San Antonio.

6.0 Socio-economic Dimension (SED)

Fig. 7 presents the indices for the socio-economic dimension of the three barangays with three attributes. All of the measured indices are categorized as "exposed to risk". Highest readings are exhibited in Makulapnit, (4.26) and Hinapulan (4.14) for limited access to credits and microfinance. Distance to the main center for credits and

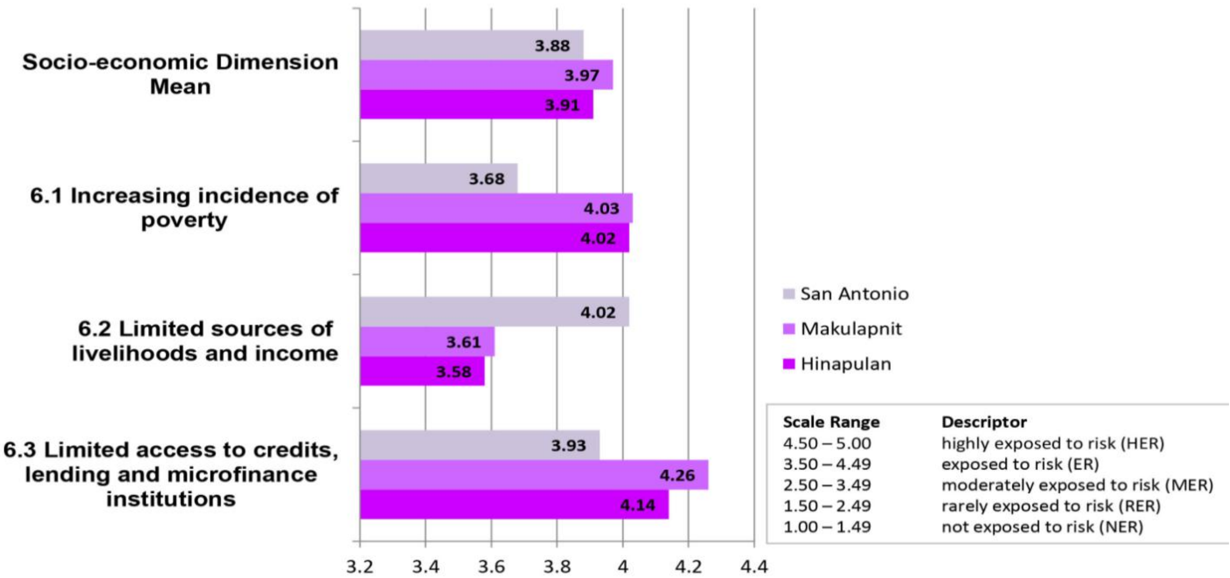

Fig. 7. Socio-economic indices of barangays Hinapulan, Makulapnit and San Antonio.

finance can be a factor, aside from the fact that during typhoon season, the roads are almost impassable to vehicles. As such, when a disaster occurs, people can find difficulty in accessing the source of money.

Makulapnit and Hinapulan and recorded "exposed to risk" due to increasing poverty, with indices of 4.03 and 4.02. Majority of the households are engaged to artisanal farming, unlike in San Antonio, with an index of 3.68. Some households in San Antonio have family members with regular income and some are working abroad. But the sources of livelihoods and income in their locality are so scared due to increasing soil acidity that can be related to mine wastes.

The general mean of the three attributes that comprised the socio-economic dimension of the barangays showed no significant differences at the 5% level

CONCLUSION

This study reveals that under the hydro-meteorological dimensions, all the communities are "highly exposed to risk" to typhoon frequency and severity. Hinapulan is "highly exposed" to extreme precipitation and scarcity of potable water supply as these contaminated the waters with heavy metals.

Under the geo-physical dimension, the communities are "highly exposed" to erosion, siltation and heavy metals contamination of rivers and streams. Hinapulan is "highly exposed" to destruction due to its topography since major households are located at the lower part of the eroding mountain of mine wastes.

For food and agricultural dimension, increasing soil acidity makes San Antonio and Hinapulan "highly exposed to risk", due to the eroding mine wastes and contaminated rivers and streams, especially during rainy season. The three communities are "exposed to risk" due to crop infestation, while Hinapulan and San Antonio are "exposed to risk" with the use of agrochemicals in farming.

Under household wastes dimension, the communities are "exposed to risk" on domestic household wastes, non-biodegradable wastes, like plastics due to unsustainable disposal of them in open spaces.

For human health dimension, the communities are "exposed to risk" with regard to malnutrition, increasing incidence of diseases and number of PWDs and vulnerable individuals

Finally, for the socio-economic dimension, the communities are "exposed to risk" with increasing poverty, limited livelihood and income and limited sources of credits and microfinancing institutions.

The above findings could serve as a basis in crafting a working disaster preparedness enhancement program to address the possible risk that the communities are facing in the future that can be triggered by climate change.

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