Typhoon Awareness and Flood Management Measures: The Case of Barangay Santo Domingo, Bay, Laguna, Philippines

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ABSTRACT — *The Philippines is prone typhoons due to its geographical location. The municipalities of Los Baños and Bay in the province of Laguna are highly flood-prone due to their proximity to Laguna de Bay or Laguna Lake. Large areas of Bay fall within the watersheds of Mt. Makiling Forest Reserve (MMFR) which are tributaries to the lake. The back flow of water into the trubutaries during heavy rainfall can cause flooding and result to socio-economic and physical impacts. The study aims to: determine the association of typhoon awareness, mitigation practices, and resilience practices with the socio-economic and socio-demographic profile of Barangay (village) Santo Domingo residents; generate a Flood Susceptibility Map, map the designated evacuation sites using Geographic Information System (GIS); and provide recommendations to promote awareness and reduce the impacts of typhoon. Ninety-six households were selected randomly based on the sampling design with 95% confidentiality. Key Informant Interviews (KIIs) and Socio-economic surveys (SES) were also conducted. STATA ver. 12 and Fisher's exact test were used to evaluate the significance of the socio-economic and socio-demographic components in relationship to awareness, mitigation, and resilience. Barangay Santo Domingo has high level of awareness (0.9647), high level of mitigation practices (0.8303) and high level of resilience (0.8842). The monthly income of respondents has a strong correlation with mitigation practices while house ownership signifies moderate association to resilience practices. Chi-square test of independence showed that there is no significant difference among the puroks (zones within the barangay). Based on the generated Flood Susceptibility Map, majority of the land area (197.23 hectares) of Barangay Santo Domingo belongs to the high susceptibility category which led to the identification of six evacuation sites. Awareness is necessary for disaster preparedness. Effective planning and management are essential to increase awareness and reduce the detrimental effects of flooding.*

Keywords — *awareness, mitigation, resilience, flood*

I. INTRODUCTION

Flooding is one of the most devastating types of natural disasters; however, disasters can also be man-made that can take a toll on the state of nature, sometimes on a sudden occurrence and sometimes its effects slowly increase through time (USAID, 2011). Human advancements like urbanization and technological developments may cause disasters and affect the balance of nature.

Disaster mitigation is a term used for a set of methodology which can eliminate or reduce the risks or even impacts caused by hazards in a specific area for a specific scenario (Public Safety Canada, 2015). Disaster mitigation may vary according to a specific hazard, human or natural, or they may also refer to approaches which apply to many disaster scenarios. Resilience refers to the "*ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions*" UNISDR (2009). The ecosystem or area's ability to "resile" depends on its manpower, available resources and organizational direction, which dictates the state of the area's closeness to its "original state" whether it is really close or far from it.

The Philippines is a small archipelagic country located in between the South China Sea and Northwest Pacific Ocean consisting of 7,107 islands across 1,850 km from north to south, with a total coastline of 235,973 km long, and a total land area of approximately 300,000 sq. km. (PhilAtlas, 2020). It has land forms that vary from flat fields that grow agricultural crops for food production, to numerous hills and valleys, and a vast amount of mountains. It is exposed to varied temperatures and precipitation, to which climatic status is further affected by alternating rotation of drought and flood. Typhoons often pass through this archipelagic country with varying levels of intensity among the provinces across the nation (Human Development Network, 2013). The Philippines is prone to typhoons and tidal waves because it is situated in the most active typhoon belt of the Pacific (Steinberg, 2000).

In 2009, typhoon Ondoy (Ketsana) swept the Philippines and was dubbed as one of the worst typhoons that caused disastrous flooding in the National Capital Region (NCR) and nearby provinces (Romulo, 2009). More than 4.9 million people were affected wherein 464 were killed, 529 were injured, and 37 people went missing. The typhoon and flooding caused 11 billion pesos worth of damage to agriculture and infrastructures. The flooding led to leptospirosis outbreak, which was more than half of the year's reported cases. Typhoon Milenyo (Xangsane) was the 2006's thirteenth tropical cyclone which struck the Philippines and caused flooding in the NCR and Regions IV-VII resulting to 6.6 billion pesos worth of infrastructural and agricultural damage (GMA, 2009). Typhoon Glenda (Rammasun) is one of the most recent typhoon that affected the Philippines, leaving a staggering damage worth 38 billion pesos on agriculture and infrastructure. This typhoon affected 4.6 billion people (NDRRMC, 2014).

` The Philippines experience numerous disastrous typhoons that cause flooding, resulting to difficulty in coping brought about by socio-economic and physical impacts. Laguna province is one of the most affected by flooding due devastating typhoons. Municipalities around Laguna de Bay are highly flood-prone areas (Ardales et al., 2015). Bay covers 4,160.76 hectares of land area and is divided to 15 villages or *barangay (*DILG Region IV-A, 2016*)*. It is surrounded by Laguna de Bay (Bantayan, et *al.*, 2014).

The study aims to: determine the association between typhoon awareness, mitigation practices and resilience practices with the socio-economic and socio-demographic profile of Barangay Santo Domingo residents; generate a Flood Susceptibility Map; map the designated evacuation sites in Barangay Santo Domingo using Geographic Information System (GIS); and provide recommendations to promote awareness and reduce the impacts of typhoons. Results of the study will be used to improve flood management measures in Barangay Santo Domingo. The generated flood susceptibility map and evacuation site map will serve as tools to facilitate disaster management including vulnerability reduction, preparedness, prevention, mitigation, response, and relief.

II. RESEARCH METHOD

Bay is a second class income municipality situated southeast of Manila. The study site is Barangay (village) Santo Domingo, one of the fifteen villages in the town of Bay in Laguna Province (Region IV-A). The barangay has a total land area of 211.74 hectares with a population of 8, 805 (Barangay Contingency Plan, 2016). It has seven puroks (zones) and several private residential areas (subdivisions) comprised of agricultural, coastal, and lowland areas. Maitim River, a tributary to Laguna de Bay (Laguna Lake Development Authority, 2016) traverses this village. Bay has an average annual rainfall of 2,020 mm while the average temperature is 27.1°C (Climate-Data.org, 2017). It belongs to Type III climate with a short dry season for a period of one to three months and it is characterized by the absence of very pronounced maximum rain period (Bareja, 2011).

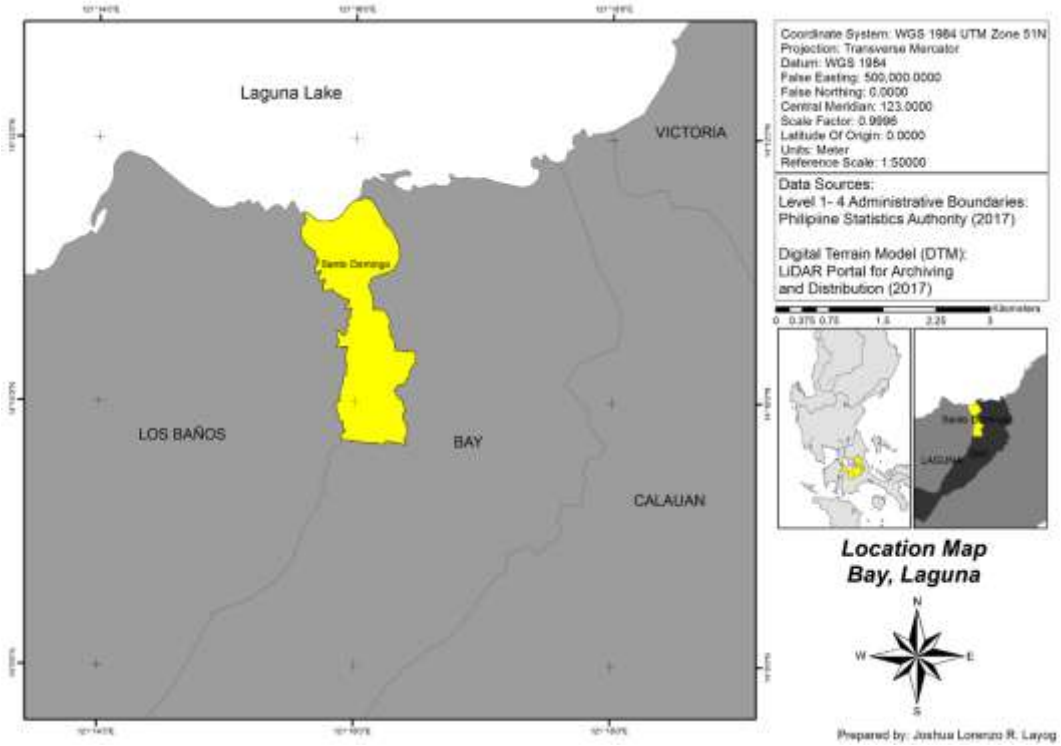

Fig. 1. Location of Study Site

Ninety-six (96) households were selected randomly based on the sampling design with 95% confidentiality. Twelve respondents were selected from each purok (zones within the barangay) to answer the structured survey questionnaire. Key Informant Interviews (KIIs) were also conducted to determine existing programs associated to typhoon preparedness in Barangay Santo Domingo. STATA ver. 12 and Fisher's exact test were used to determine the association of the socio-economic and socio-demographic components to awareness, mitigation, and resilience. To further determine the strength of association, Cramer's V coefficient was also computed using STATA. Chi-square test of independence was used to evaluate the significant difference among the puroks when it comes to awareness, mitigation and resilience practices. Points of Interest (POIs) were recorded using a Global Positioning System (Garmin 62SC). The maps were generated using QGIS2.18.13 with GRASS (Geographic Resources Analysis Support System) 7.2.1 and ARCGIS version 10.3.1. The following thematic maps were used for map generation: administrative/municipal boundaries, road networks, elevation, land use, slope, soil type, and tributaries/waterways.

III. RESULTS AND DISCUSSION

3.1 Socio-economic Profile of the Respondents

The respondents were household heads of the seven (7) puroks in Barangay Santo Domingo namely Daang Bakal, Ibaba, Ilaya, Kabaritan, Pookan, Sipit, and Tabon. Respondents from the three (3) subdivisions namely Bay Garden, Lakeshore, and Cambria were also included. According to a personal interview with Savariz (2017), the subdivisions are private residential areas and are not included in any purok. However, these subdivisions were considered as one site for proper representation.

Majority of the respondents (35%) in the puroks belong to the 26-35 years old age bracket. Sixty-seven percent (67%) of the respondents were female. Female respondents predominate in each purok because men are working most of the time. This is similar to the findings of Gayuma (2002) that generally reflect the condition of the Filipinos where most of the males during daytime are out to earn for a living, leaving behind women to take care of the kids and carry out household chores. Majority of the families (65%) have one to five (1-5) household members. Forty-one percent (41%) of the respondents finished high school level while the other respondents

finished either elementary, college, vocational course or Alternative Learning System (ALS) or did not take any formal education.

Majority of the respondents in each purok were unemployed or housewives (57%). The other respondents were fishermen, farmers, employees, and entrepreneurs. Fifty-five percent (55%) of the respondents have a very low monthly income ranging from PhP 1,000.00 to PhP 5,000.00. This was followed by the income range of PhP 6,000.00 to PhP 10,000.00 which is still low. Several respondents in the subdivision has a monthly income of PhP26, 000.00 and above which is expected because most of the respondents who graduated from college live here. Results of the study show that majority of the respondents have low monthly income far lower than the required per capita poverty threshold of PhP 11,000 per month for a family of five (5) to meet the food and the non-food needs of the entire family (Benigno, 2004). Moreover, based on the assessment of the National Economic and Development Authority (NEDA), such income is below the poverty line. NEDA pegged the threshold income of a family of five (5) at PhP13, 000.00 to PhP15, 000.00 to be above the poverty level (Lugares, 2007). In 2015, the poverty incidence in the municipality of Bay is 2.73 % which is lower compared to the national average of 21.6% (Philippine Statistics Authority, 2019).

Eighty-two percent (82%) of the respondents have their own houses with purok Sipit having the highest relative frequency followed by puroks Ilaya, Daang Bakal, and Kabaritan. Emphasis is given to purok Sipit which has the highest relative frequency of very low income but has the highest relative frequency also when it comes to house ownership. Some respondents have concrete houses (45%) and the others own a combination of wood and concrete (45%) while the remaining 10% have wooden houses.

Most of the respondents (73%) in the barangay have at least two or three appliances/gadgets (cellphones, televisions, radios, and computers) used for accessing information.

3.2 Correlation of Socio-economic and Socio-demographic Components to Typhoon Awareness, Mitigation Practices and Resilience Practices

Table 1 shows that the socio-economic and socio-demographic profile of the respondents have no significant association with typhoon awareness. This result is contrary to a study conducted by Besin et al. (2017) in Barangay Bangad, Talim, Binangonan, Rizal, Philippines wherein socio-economic status has a low positive correlation to awareness, preparedness, level of recovery, and speed of recovery to typhoons. However, according to Pampel (2014), though the socio-economic status of individuals contributes to increase their environmental concern, the relationships are modest and differ to some degree for education, occupation, and income.

Table 1. Correlation of socio-economic and socio-demographic components to typhoon awareness, mitigation and resilience practices

Component	Typhoon awareness	Mitigation practices	Resilience practices
	p-value	*p*-value	*p*-value
Age	0.147	0.123	1.000
Sex	0.700	0.744	0.171
Highest Educational Attainment	0.714	0.751	1.000
Work	1.000	0.227	0.350
Monthly Income	1.000	0.005*	0.684
Number of Household Members	1.000	0.211	0.336
Media Access	1.000	1.000	1.000
House Ownership	1.000	0.717	0.057*
House Structure	1.000	1.000	0.664

*statistically significant (*p*-value ≤ 0.05)

Based on Fisher's exact test, only the monthly income was shown to have association with mitigation practices with a corresponding p-value of 0.005 (Table 1). To further determine the strength of this association, the Cramer's V coefficient was computed. The range values for this coefficient are as follows: 0.01-0.10 (weak correlation); 0.11-0.30 (moderate correlation); and higher than 0.30 (strong correlation). A coefficient of 0.3328

signifies strong association. As shown in Table 1, respondents with higher income would tend to apply mitigation measures which can be attributed to their financial capability compared to the respondents with low income. This result is similar to the findings of Reganit (2005) which states that income affects the coping mechanisms at different stages of flooding – before, during, and after. Households with lower income are more vulnerable than households with higher income. Those with higher income can introduce measures that could make them safe. Likewise, they can recover easily due to their financial capability (Reganit, 2005).

When it to comes to resilience which refers to the ability to "spring back from" a shock (UNISDR, 2009), only the house ownership is found to have association with a corresponding *p*-value of 0.057 (Table 1). The Cramer's V coefficient for this is .02075 (moderate association). This can be attributed to the fact that people tend to be more concerned with safety (e.g. repairing of houses after a typhoon) if they own the property. In addition, the United Nations International Strategy for Disaster Reduction (UNISDR, 2009), stated that the resilience of a community in relation to potential hazard events is determined by the degree to which the community has the necessary resources (e.g. financial resources) and is capable of organizing itself both prior to and during times of need. However, for the case of Barangay Santo Domingo, income does not have association to respondents' resilience to typhoon since majority of the respondents have a very low income.

Table 2. Estimated proportion of respondents' per purok in relation to their awareness, mitigation practices, and resilience to typhoon

Purok	Estimated proportion of respondents who are aware	Estimated proportion of respondents who perform mitigation practices	Estimated proportion of respondents who are resilient
Brgy.Santo Domingo	**0.9647 [0.9385, 0.9909]***	**0.8303 [0.7095, 0.9511]***	**0.8842 [0.7889, 0.9794]***
Kabaritan	1.0000 [0.7575, 1.0000]*	0.7500 [0.4677, 0.9111]*	0.8333 [0.5520, 0.9530]*
Daang Bakal	0.9167 [0.6461, 0.9851]*	1.0000 [0.7575, 1.0000]*	0.7500 [0.4677, 0.9111]*
Ibaba	0.7500 [0.4677, 0.9111]*	0.8333 [0.5520, 0.9530]*	0.9167 [0.6461, 0.9851]*
Pookan	0.8333 [0.5520, 0.9530]*	1.0000 [0.7575, 1.0000]*	0.7500 [0.4677, 0.9111]*
Sipit	1.0000 [0.7575, 1.0000]*	1.0000 [0.7575, 1.0000]*	0.9167 [0.6461, 0.9851]*
Ilaya	0.9167 [0.6461, 0.9851]*	0.8333 [0.5520, 0.9530]*	0.9167 [0.6461, 0.9851]*
Tabon	0.8333 [0.5520, 0.9530]*	0.6667 [0.3906, 0.8619]*	1.0000 [0.7575, 1.0000]*
Subdivisions	1.0000 [0.7575, 1.0000]*	0.8333 [0.5520, 0.9530]*	0.9167 [0.6461, 0.9851]*

**[Lower Limit, Upper Limit] is the confidence interval estimate at 95% level of confidence*

Typhoon Awareness. As shown in Table 2, the overall typhoon awareness of Barangay Santo Domingo is high with a weighted proportion of 0.9647 with one (1) as the highest. This maybe associated to the active awareness campaign through the Barangay Risk Reduction Management Council (BRRMC). The respondents from puroks Kabaritan, Sipit, and subdivisions have the highest awareness with equal weighted proportion of 1.0000, respectively. This may be due to their location because purok Kabaritan and the subdivisions (particularly Bay Garden) are adjacent to Laguna Lake. It was also confirmed during the Key Informant Interview (KII) that these two parts of the barangay are frequently flooded especially during strong typhoons or heavy rainfall. Similarly, purok Sipit is near Maitim River that makes it flood-prone. Some of the typhoons that led to flooding in the barangay are typhoon Glenda in 2014, Ondoy in 2009, and Milenyo in 2006. Typhoon Ondoy brought flashfloods and submerged purok Kabaritan and Bay Garden for almost three months due to overflowing of Laguna de Bay. The flood level reached up to two meters according to the respondents. In addition, typhoon Glenda resulted to damages in infrastructure.

Since Kabaritan, Sipit, and the subdivison respondents frequently experience flooding, they are expected to be aware of its causes and other issues associated with it. On the other hand, purok Ibaba has a lower awareness (0.7500) which can be attributed to its location which can hardly be reached by mobile patrol responsible for early warning announcement and dissemination of safety information.

Mitigation Measures. Based on the survey results, majority of the residents heed to hazard forecasting and Early Warning System (EWS). Flood preventive measures such as the use eco-bags, waste segregation, recycling, composting, backyard gardening, and tree planting are being practiced in Daang Bakal, Pookan, and Sipit with equal weighted proportion of 1.0000 for each as shown in Table 2. These three puroks apply of flood

preventive measures because they are flood-prone. This conforms to the study of Palmer (1993) which revealed that the amount of experiences of the respondents is the strongest predictor of their environmental concern.

In addition, most of the households in Daang Bakal, Pookan, and Sipit are into backyard gardening due to availability of space especially in purok Sipit. The Materials Recovery Facility (MRF) is also located in purok Daang Bakal which maybe one of the reasons for their preventive measures particularly waste segregation. Contrarywise, purok Tabon had the lowest level of mitigating measure (0.6667) maybe because they are located near the highway and they seldom experience flooding. In general, the mitigation practices of Barangay Santo Domingo is generally high with a weighted proportion of 0.8303.

Resilience of the Respondents. Generally, the resilience of Barangay Santo Domingo is also high with a weighted proportion of 0.8842 as shown in Table 2. Purok Tabon has the highest resilience value to typhoons and flood with a weighted proportion of 1.0000. This can be attributed to their proximity to the Barangay Hall that serves as the source of information on clean-up drives. Damages can easily be reported and they can easily seek assistance from the barangay officials during disasters. Daang Bakal and Pookan have the lowest resilience with an equal weighted proportion of 0.7500.

Chi- square test of independence showed that there is no significant difference among the puroks when it comes to awareness, mitigation and resilience practices (Table 3).

Table 3. Difference among Puroks

Variable	*p*-value
Typhoon Awareness	0.275
Mitigation Practices	0.126
Resilience Practices	0.529

3.3 Flood Management Measures in Barangay Santo Domingo

Garbage collection is done on a weekly basis. Wastes are being segregated in a Materials Recovery Facility (MRF) situated in Purok Daang Bakal. The waste materials are brought to a dumpsite in Barangay Santa Cruz, a nearby barangay. Composting sites are not yet established but three big junkshops are operating in the area. Although, there are some stores that require their customers to "bring their own bag," single-use plastics are still prevalent. As part of the structural mitigation measures, dry boulder riprap was established along the Maitim River for flood protection.

The Barangay Risk Reduction Management Council (BRRMC) has a contingency plan for disaster preparedness. Post-typhoon meetings are also conducted for rehabilitation planning. An evacuation map is posted in front of the Barangay Hall together with the list of emergency/hotline numbers. The overflowing of Laguna de Bay serves as an indicator for purok Kabaritan residents to evacuate. The BRRMC also disseminates information and conducts monthly River Clean-Up Drive. Tree planting activities are being held every year spearheaded by either of the following: schools, Non-governmental Organizations (NGOs), Philippine National Police, and Fire Brigade. People who would like to evacuate in the occurrence of flood are picked-up by trucks. Forced evacuation is being implemented if the residents refuse to leave. Life vests and rescue boats are also available. Hand held radios are available in the barangay hall to facilitate fast communication. Furthermore, relief goods are being distributed the following day after the typhoon.

3.4 Flood Susceptibility Map

Flooding is the most common and destructive of all disasters and is considered a constant threat to life and property. Each year, flood disasters result in tremendous losses and social disruption worldwide (Lagmay et al. 2017). With population continually growing exponentially in hazard prone areas, it is anticipated that damage to infrastructure and human losses will continue to occur unless appropriate measures are immediately implemented by government (Lagmay et al., 2017) specially the respective Local Government Units (LGUs).

Geographic Information System (GIS) is frequently used as a tool for disaster risk management. It provides an effective way of assembling information from different maps and digital elevation models (Sanyal & Lu, 2003) such as elevation, slope, soil classification, land use, and road networks.

The categories of flood susceptibility are: low-moderate susceptibility and high susceptibility. Based on Figure 2, majority of the land area (197.23 hectares) of Barangay Santo Domingo belongs to high susceptibility category. A portion of the barangay belongs to the low-moderate susceptibility (14.51 hectares) that are located near the highway or distant to Laguna de Bay.

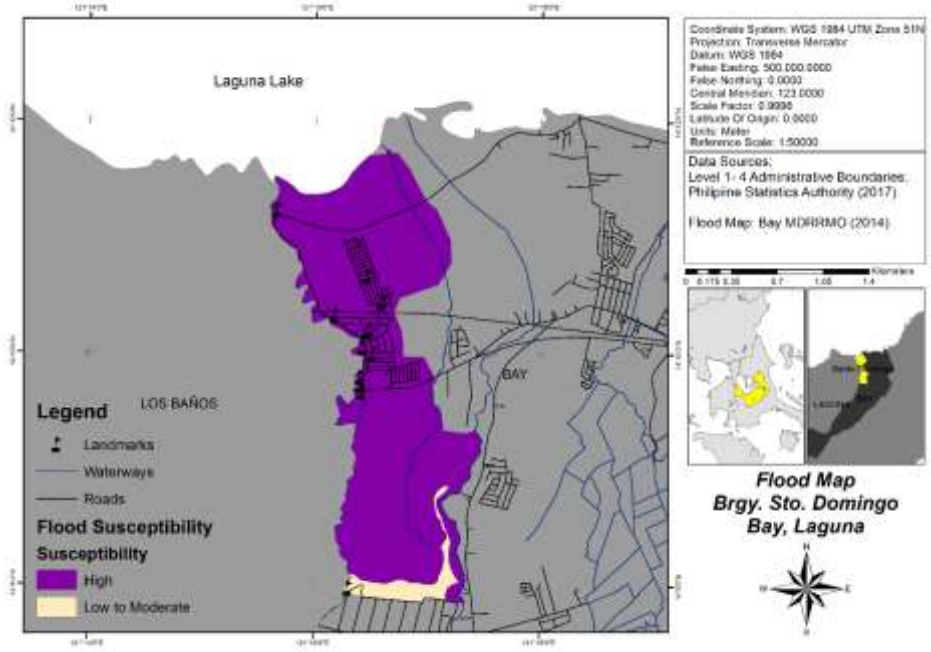

Figure 2. Flood Susceptibility Map of Bgy. Santo Domingo

3.5 Evacuation Sites

Road networks show possible evacuation routes in the event of flooding. The identified evacuation sites are shown in Figure 3.

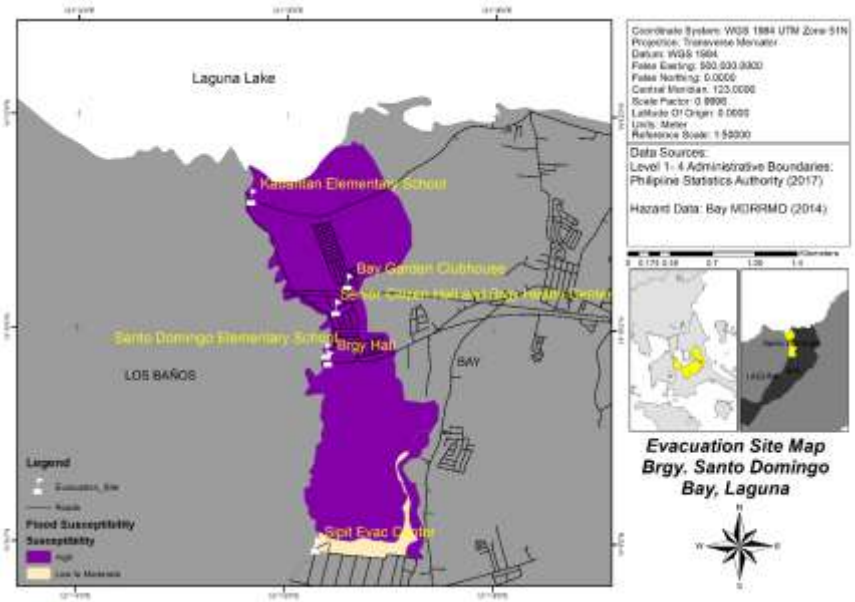

Fig. 3. Location of Evacuation Sites in Brgy. Santo Domingo

The potential evacuation sites are: Senior Citizen Hall, Barangay Health Center, Kabaritan Elementary School, Santo Domingo Elementary School, Bay Garden Clubhouse, and Sipit evacuation center. If these areas are already fully occupied, the Bay Municipal Hall (coordinates: 14°10'50.54"N 121°17' 5.37"E) can also be used. However, the two-storey Kabaritan Elementary School is not recommended as an evacuation site because it is adjacent to Laguna Lake. Only Sipit evacuation center is located in a low-moderate flood susceptibility zone.

The steepness or incline of Brgy. Santo Domingo is predominantly from 0-5.76 % in percent rise. This indicates low possibility of soil erosion and sedimentation.Thus, landslides do not occur in the area. The dominant soil classification is Calumpang Clay which is suitable for cultivation and is subject to slight occasional overflow and slight wetness (Philrice, 2014). The high susceptibility to flood of Barangay Santo Domingo can be attributed to its soil type characterized by poor drainage and slight wetness which is subject to overflow. According to Hill et.al. (2017) the steeper the slope is, the quicker the water flows and the higher the peak discharge. This means that areas, with less slope value has a high potential to retain water because the discharge is low.

Elevation ranges from six to fifteen (6-15) meters is predominant while there are few areas within 16-20 meters elevation. The land uses of Brgy. Santo Domingo consist of agricultural/cultivated; coastal or freshwater (mainly purok Kabaritan) and residential/built-up areas. The largest portion of the barangay's land use is agricultural according to the Bureau of Soils and Water Management (2017).

The average depth of Laguna de Bay is 2.5 meters (Laguna Lake Development Authority, 2016) and its depth is continually decreasing due to siltation caused by the proliferation of fish pens. This results to persistent flooding in the low-lying coastal areas. When there is heavy rain due to typhoons, the level of water from the lake increases and eventually overflows.

The annual population growth rate of Bay, Laguna from 2010-2015 is 2.11% (PhilAtlas, 2020) and this is expected to increase and result to land use change due to the conversion of agricultural lands to subdivisions and other uses. This will result to more flooding in the absence of green spaces which play an important role in controlling storm water runoff. Increase in waste generation is a consequence of population increase and lack of strict environmental law implementation which may result to the clogging of drainages and siltation in Laguna Lake. If people will continue with BAU (Business As Usual scenario on managing resources, the level of flood will increase through time due to anthropogenic activities and will exacerbate the problem on climate change impacts.

The frequency of typhoons is 1.5 times per year in Region IV-A (Bareja, 2011). Extreme weather events contributed by climate change is expected to rise. Thus, flood hazard mapping is required for appropriate land use planning especially in flood-prone areas. This also serve as a planning tool for mitigation practices and efficient response efforts (Bapulu & Sinha, 2005). Maps can be used for emergency planning, disaster prevention and preparedness, recovery, post disaster reconstruction and rehabilitation, vulnerability and risk reduction, provision of evacuation shelters, and flood-proofing measures (Adeniran, 2014).

IV. CONCLUSION

Barangay Santo Domingo has high level of awareness (0.9647), high level of mitigation practices (0.8303) and high level of resilience (0.8842). However, based on the results, typhoon awareness has no correlation to any of the socio-economic and socio-demographic components. They also have high level mitigation practices but only the income is significally correlated with their mitigation practices. Moreover, they exhibit high resilience to typhoon but only the house ownership showed significant association with it. Chi-square test of independence showed that there is no significant difference among the puroks when it comes to awareness, mitigation practices, and resilience practices. A large portion of the entire land area of Barangay Santo Domingo belongs to high flood susceptibility category. The six identified evacuation sites in the barangay are: Senior Citizen Hall, Barangay Health Center, Kabaritan Elementary School, Santo Domingo Elementary School, Bay Garden Clubhouse, and Sipit evacuation center. The Bay Municipal Hall can also be used if all the designated evacuation centers are fully occupied.

V. RECOMMENDATIONS

The community should maintain regular IEC (Information, Education and Communication) campaign on flood preventive measures. Climate change adaptation and disaster risk management should be integrated in the school curriculum to enhance the preparedness and responsive capabilities of children and their families to disasters. Strengthening the Disaster Risk Reduction Management (DRRM) committees through capacity building is also needed. Composting, selling of recyclable materials, and bringing of own eco-bags should be promoted to reduce wastes that clog drainages. RA 9003 otherwise known as Ecological Solid Waste Management Act must be strictly implemented. Structural and non-structural flood mitigation measures should also be improved. Since majority of the designated evacuation sites are located in areas highly susceptible to flood, identifying potential evacuation sites near Barangay Santo Domingo should also be considered.

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