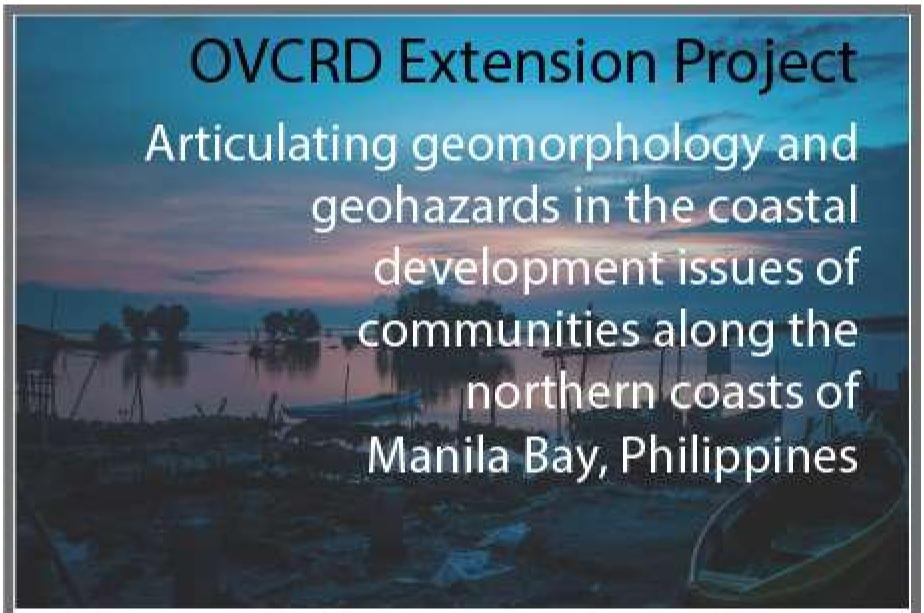

OVCRD Extension Project

Articulating geomorphology and geohazards in the coastal development issues of communities along the northern coasts of Manila Bay, Philippines

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This terminal report

Articulating geomorphology and geohazards in the coastal development issues of communities along the northern coasts of Manila Bay, Philippines

For the OVCRD project with Project No. 181818 UPD-EG was prepared by the faculty and volunteers of the National Institute of Geological Sciences, University of the Philippines - Diliman, Quezon City.

August 2019

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Abstract

The proposed Bulacan Aerotropolis Project along the coast of Manila Bay in Barangay Taliptip, Bulakan, primarily aims to decongest the crowded Ninoy Aquino International Airport (NAIA) and boost the local economy of Bulakan and neighboring towns. Ironically, the project appears to lack concrete plans that address the potential displacement of local fishing communities. There also have been issues raised on the transparency of the project in its various stages such as the approval (EIA and ECC) and implementation. Thus, many residents express resistance to the proposal.

Vulnerability to geohazards has been used to promote acceptance of the project. As such, the study aims to foster discussions on the attendant geohazards and risk, which will be the basis for residents to make informed decisions, whether to remain in their communities or relocate. This goal was accomplished through a review of geohazards in the area, validation of their impact on communities, and communication of the results to the local community. Furthermore, the perceived effects of the Aerotropolis Project to the community were gathered through interviews.

Barangay Taliptip is constantly affected by floods, storm surges, tides, and rarely, earthquakes. Through the years, community resilience grew from an effective early warning system, timely evacuation, and a culture of rebuilding after major storms. Regardless of economic status and periods of settlement, the residents preferred to remain in their communities because of a combination of factors such as livelihood and ease of living. Their desire to remain in their communities stemmed from their rootedness and a sense of belongingness. In the absence of concrete plans by the government to reduce project impact on the communities, the future of Barangay Taliptip residents remains uncertain.

The planned site for airport construction is fraught with geohazards due to its geologic, geomorphological, and climatological setting. Ground conditions are also not suitable for constructing large infrastructures like airports because the selected site is prone to settlement, liquefaction, and flooding. It is recommended that an alternative site for the airport be identified.

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Introduction

In 2017, the Manila Bay Integrated Flood Control, Coastal Defense and Expressway Project was identified as one of the priority projects under the current administration's infrastructure development strategy . This involves the construction of a dike that straddles the northern shore of Manila Bay that would carry a coastal expressway, as well as multiple reclamation projects for mixed-use development (Fig. 1A), expansion of the Manila Harbor, and the construction of a new international airport, the Bulacan Aerotropolis Project - New Manila International Airport (Fig. 1B). The project mainly aims to construct an alternative transport hub to the heavily congested NAIA, integrated with other developments including building a new seaport to complement the existing Manila Harbor, and construction of an alternative road transport link between Manila and Bataan.

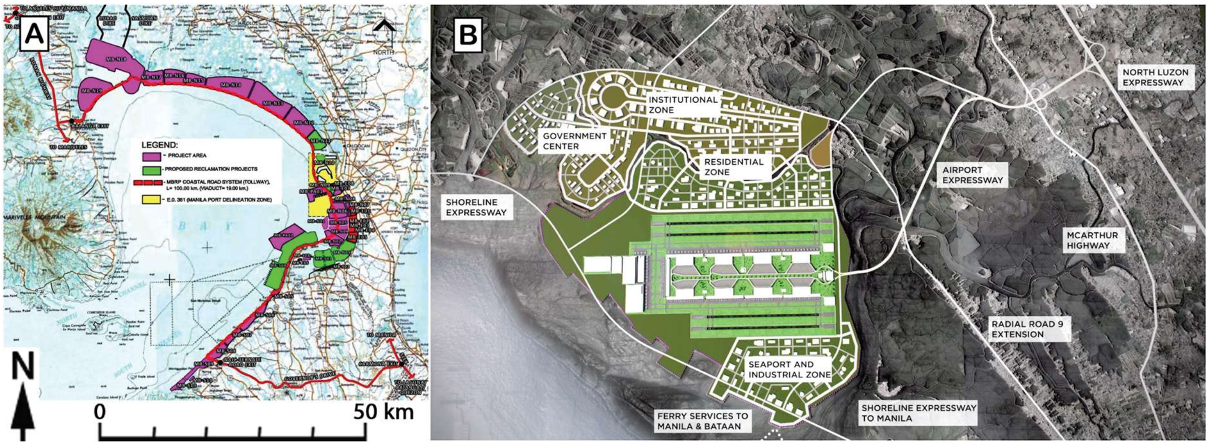

Figure 1. A. Reclamation proposals around Manila Bay (Rodolfo, 2013). **B.** Master plan of the Bulacan Aerotropolis Project - New Manila International Airport (SMC Infrastructure, 2018).

The project was proposed by the Coastal Development Consortium (CDC) of San Miguel Holdings Corp. and New San Jose Builders Inc. In spite of the benefits, this project would entail the removal of coastal communities and the destruction of ecological ecosystems in Navotas, Bulacan, Pampanga and Bataan to give way to an expressway, airport and city complex (Fig. 1B). Vulnerability to geohazards has been used to persuade the people to accept the project despite minimal information provided during consultations.

If these proposed projects will not be properly designed and implemented, they may pose geological hazards and increase the vulnerability of adjacent coastal communities to disasters. In order to minimize the impact of the project, a thoroughly conducted Environmental Impact Assessment (EIA) and Environmental Impact Statement (EIS) is essential. These documents serve as important bases for the issuance of an Environmental Compliance Certificate (ECC) that contains the commitments of the proponent to comply with the conditions set by the government. Another important aspect of the ECC is to ensure the well-being of affected communities. Thus, community consultation and participation are crucial in the conduct of impact studies of the project.

Study Area

Barangay Taliptip (14° 46' 00.5160" N, 120° 53' 47.9040" E) is located along the northeastern shore of Manila Bay in the town of Bulakan, Bulacan. It is located at the southern portion of the Central Luzon Basin covering the provinces of Bulacan, Pampanga, Bataan, and the cities of northwest Metro Manila termed KAMANAVA (i.e., Kalookan, Malabon, Navotas, and Valenzuela) (Fig. 2). Taliptip has a total land area of 23.8 km^2, and a population of 5,490 residents with nearly 20% of the population between the ages of 5 to 14 (Philippine Statistics Authority, 2015).

Figure 2. Map of the northern Manila Bay region and parts of Central Luzon, with road networks and municipalities (Rodolfo et al., 2003).

Significance of the Study

The community needs to understand the attendant and possible hazards and risk associated with the infrastructure to be built. Education and awareness enhancement can be achieved through direct engagement with the community. The data generated from this study aids the community to make informed decisions. This study, along with other related initiatives hopes to influence the government and private entities to uphold social justice in the aggressive promotion of large-scale projects that undermine the rights of the community for sustainable development.

Objectives

This extension project aims to contribute to the comprehensive discussion of coastal development issues faced by communities along the northern coasts of Manila Bay. More specifically, this project aims to:

1. Conduct geohazard assessment particular to deltaic and coastal environments in Brgy. Taliptip, Bulakan;
2. Integrate the assessment to the overall discussion on the planned Bulacan Aerotropolis project;
3. Facilitate discussions with the community to effectively communicate the geohazards and the effects of coastal development; and
4. Help create a science-based and community-centered EIA in conjunction with other related initiatives.

Methods

Preliminary analysis involved a review of previous works on geomorphology and geohazard assessment of the area, including thematic maps. Courtesy calls to the local government unit (LGU) was made, and organizational meetings with partner organizations and local leaders were carried out. Fieldwork was conducted to verify the geomorphological features, sedimentological processes, and associated hazards in Brgy. Taliptip and other locations around the Pampanga River Delta. Alongside the fieldwork were interviews and Focus Group Discussion (FGD) performed with the communities in order to validate the preliminary analysis based on previous works. Thirty-five residents in seven sitios of Brgy. Taliptip participated in the interviews. These were conducted to further enrich the results, particularly for historical information regarding hazards in the area, and background information regarding the Aerotropolis Project. The results were processed and collated for presentation and discussion with the community and partner organizations (AGHAM, AKAP KA). Community feedback through post-seminar consultation was conducted to further validate the study. Project evaluation was conducted through a SWOT analysis and project workshop.

Geologic and climatologic setting

Regional and local geology

Tectonics

The Philippines is located at the boundary of the Phiilippine Sea Plate and the southeastern margin of the Eurasian plate (Fig. 3). It is characterized by a complex system of subduction zones, collision zones, and marginal basins (MGB, 2010). Two major tectonic elements/geologic blocks form the Philippines, the Philippine Mobile Belt (PMB) and the Palawan Continental Block (PCB).

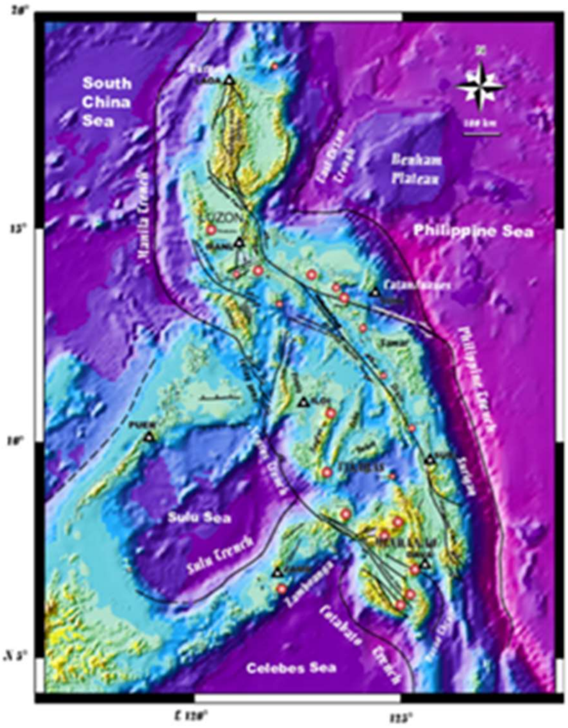

Figure 3. Simplified tectonic map of the Philippines showing major trenches and faults (MGB, 2010).

The Philippine Mobile Belt is a complex collage of arc, ophiolitic, and continental terranes bounded by oppositely dipping subduction zones accreted through the oblique convergence along the Eurasian - Philippine Sea plate boundary (Santos-Yñigo, 1949; Karig, 1983; Garcia et al., 1985; Ringenbach, 1993; Aurelio, 2000). This oblique convergence is accommodated in three linear deformation zones, a western east-dipping series of subduction zones (Manila, Negros-Sulu, Cotabato Trenches), an eastern west-dipping zone of subduction (Philippine Trench, East Luzon Trough), and the sinistral Philippine Fault Zone (PFZ) in the middle.

The Philippine Trench forms the eastern boundary of the Philippine Mobile Belt, where the Philippine Sea Plate has subducted since the Miocene. Another west-dipping subduction zone is the young East Luzon Trough to the north of the Philippine Trench, characterized by a poorly developed Wadati-Benioff zone and the lack of an associated volcanic arc (Bautista et al., 2001; MGB, 2010).

The northernmost of the three western subduction zones is the Manila Trench, where the South China Sea basin subducts to form the Luzon Arc. South of the trench is a broad collision zone between the PMB and PCB. The Negros-Sulu trench is located further south of the collision zone, where the Sulu Sea basin is being subducted. The southernmost zone is the Cotabato Trench, where the Celebes Sea basin subducts underneath Mindanao and Sangihe islands.

The Palawan Continental Block is a small terrane of mainly continental origin believed to have been derived from the Eurasian margin. It was rifted during the opening of the South China Sea basin in the Oligocene-Early Miocene (Yumul et al., 2005; Barckhausen et al., 2014) and collided with the PMB in the Middle Miocene (Karig et al., 1986, Yumul et al., 2008).

The Manila Bay is located in the southern part of Luzon, and is part of a marginal basin within the PMB. This marginal basin is bound by the Luzon Arc to the west, the Sierra Madre Range to the northeast, and the volcanic centers of the Macolod Corridor to the east-southeast.

General geology and stratigraphy

The Manila Bay forms the southern part of the Central Luzon sedimentary basin. It was formed from two distinctly different sources, with the northern Manila Bay being a tidal-river delta complex of different fluvial systems (Pampanga, Angat, Bulacan, Pasac) that continuously deposit sediment into the basin (Soria et al., 2005). Meanwhile, the southern part is related to the emplacement of ignimbrite sheets of Taal and Laguna calderas (Wolfe, 1981; Listanco, 1994; Catane et al., 2005; Arpa et al., 2008).

The oldest rocks in the area are the Cretaceous ophiolites and associated overlying sediments that form the basement rocks of the Sierra Madre (Fig. 4). Initial sedimentation in the Central Luzon sedimentary basin formed part of the cores of the two mountain ranges, the Southern Sierra Madre and the Zambales, during the Eocene-Early Oligocene (Bachman et al., 1983; Siringan, 1988, Encarnacion et al., 1993). A volcanic arc formed in the present-day location of the Sierra Madre range, and eroded sediments from the arc were deposited into the basin. By the Late Oligocene, oceanic crust in the west was obducted and formed the Zambales Ophiolite, presently exposed in the northern part of the Zambales Range, concurrent with volcanism and associated sedimentation occurred in the Sierra Madre in the east. With land bounding both sides, rivers dumped considerable amounts of sediment into the Central Luzon sedimentary basin, such that it became shallower despite a general rise in global sea levels at that time (Bachman et al., 1983). Sedimentation continued into the Pliocene, when the prograding deltas of the rivers eventually linked the Zambales and Sierra Madre ranges. This land grew towards the north and south, eventually leading into the present-day configuration of the basin. Figure 5 summarizes the changes in sediment deposition over time.

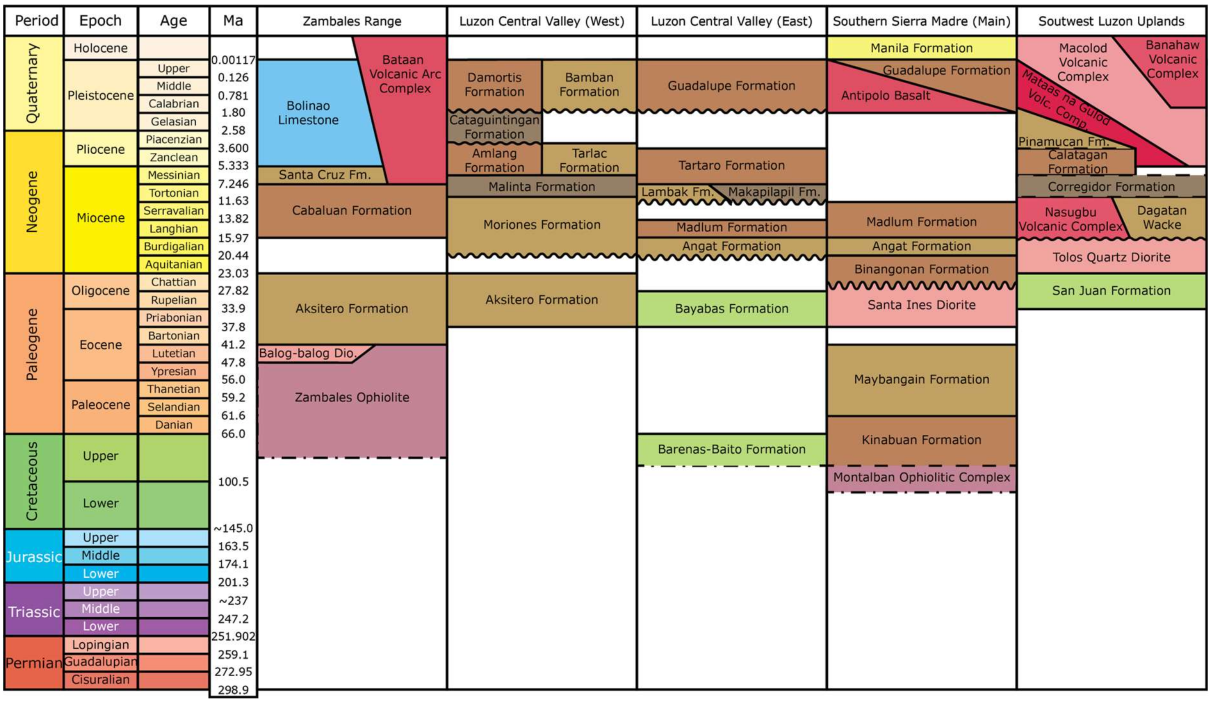

Figure 4. Stratigraphy of the regions adjacent to the Manila Bay (modified from MGB, 2010). Age names and dates (Ma) from Cohen et al. (2013; updated).

Starting from the Late Miocene, volcanic activity formed the Bataan Segment of the Luzon Arc (Fig. 4). This arc is composed of two lines of volcanic centers, the West Bataan Lineament (e.g., Mt. Pinatubo, Natib, and Mariveles) and the East Bataan Lineament (e.g., Mt. Arayat, Amorong) (De Boer et al., 1980, Defant and Ragland, 1988).

In the south, volcanism initiated along the Macolod Corridor, the volcanic province that forms the eastern and southern boundary of Manila Bay. This area contains at least two identified calderas, Taal (Listanco, 1994) and Laguna (Catane et al., 2005, Arpa et al., 2008), that have produced voluminous volcaniclastic rocks that formed the deposits in the eastern and southern Manila Bay area (Fig. 4).

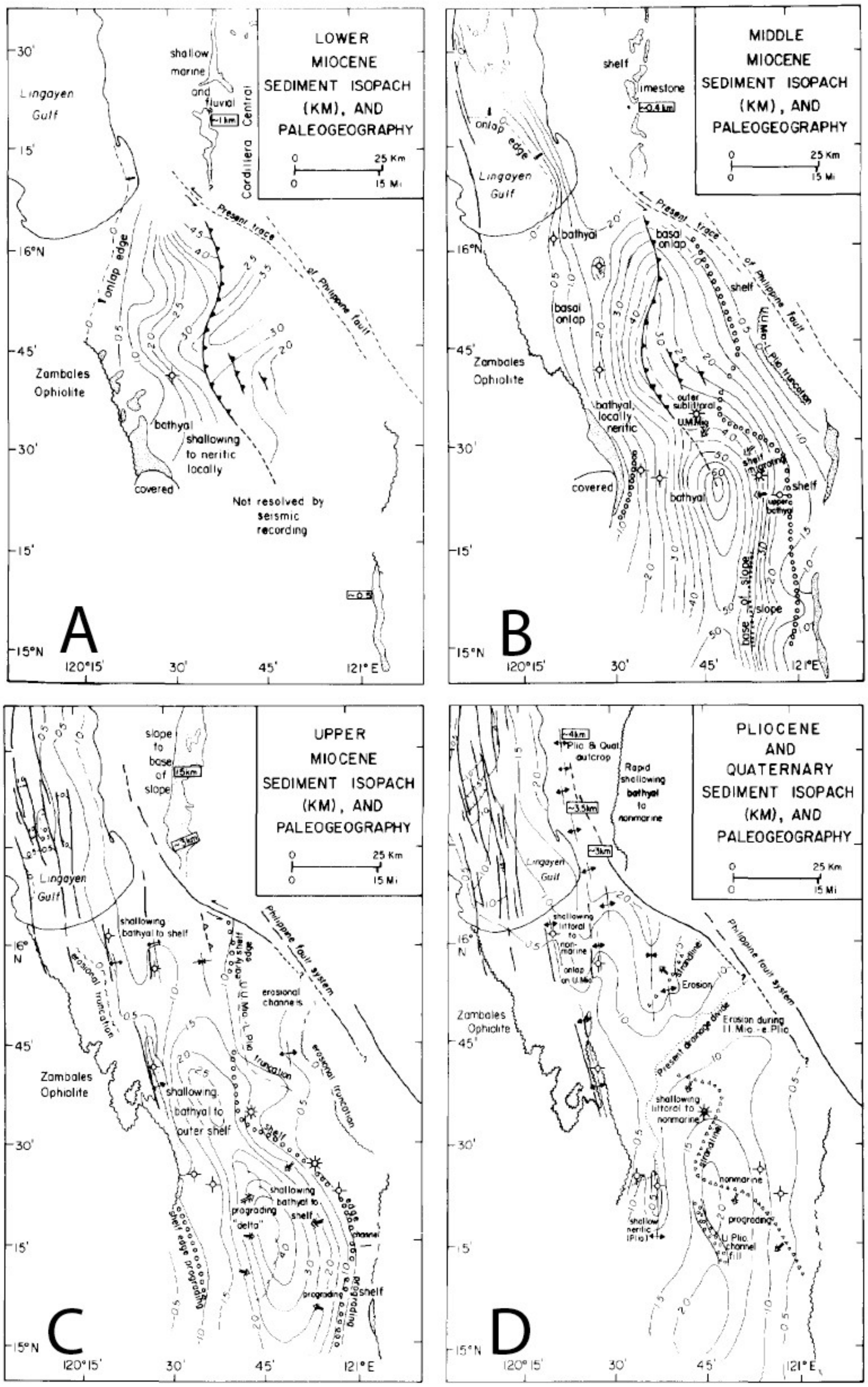

Figure 5. Sediment isopach maps (A-D) and associated paleogeography for the Central Luzon sedimentary basin (Bachman et al., 1983).

The Quaternary Pampanga Delta is characterized as a broad tidal-river delta complex (Fig. 6) of varying sand to marsh plains, and this is underlain by alluvium consisting of consolidated mud with poorly cemented clastics from the Guadalupe Formation (Soria et al., 2005). Borehole data along the KAMANAVA area exhibit Holocene marine to terrestrial sequences from 1 to 31 m thick (CTI Engineering Co., Ltd. 2001 in Soria et al., 2005). Contributing towards the west coast are volcanic debris from Mt. Pinatubo which clog the channels draining towards the Pampanga Delta (Siringan and Ringor 1997, Rodolfo et al., 2003, Siringan and Rodolfo 2003, Soria et al., 2005).

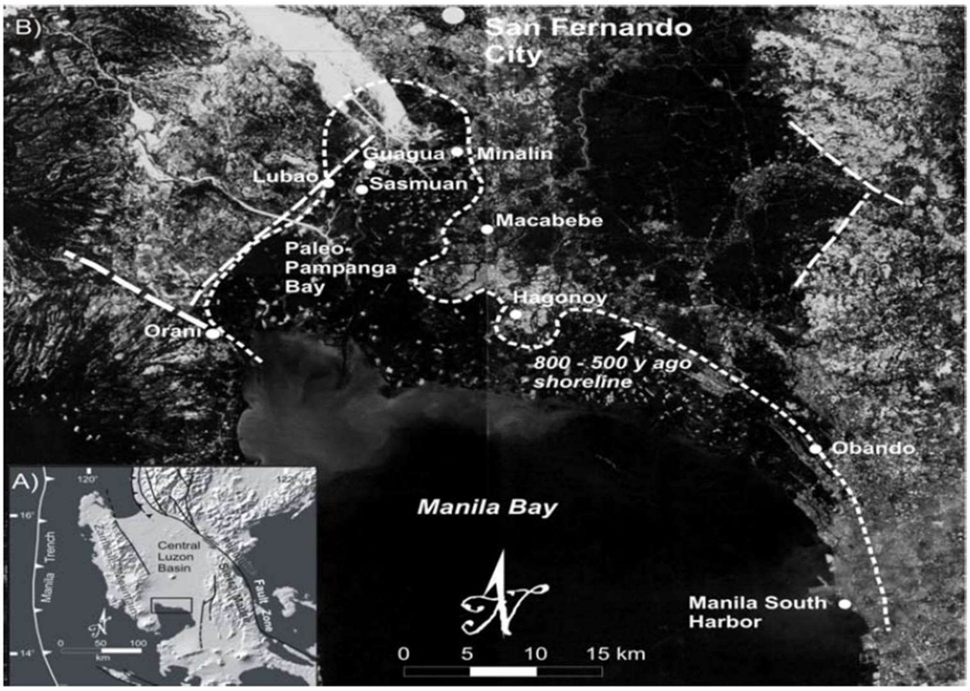

Figure 6. Paleoshoreline of the northern part of Manila Bay, circa 1500 ky, reconstructed from borehole data (Soria et al., 2005).

Structural Geology and Seismicity

The most conspicuous structure in the vicinity of the area is the Marikina Valley Fault system (MVFS). It is the closest active fault to metropolitan Manila (Fig. 7) and the most likely near-field source of large and damaging earthquakes to Manila (Wong et al., 2013). Neotectonic features associated with this active fault system indicate a dominantly dextral strike-slip motion and its recent activity is estimated to have occurred from Late Pleistocene to Holocene. The MVFS diverges from the Philippine Fault Zone at Dingalan Bay in the north and runs southwest toward the Macolod Corridor in south while passing through the eastern cities of Metro Manila, i.e., Quezon, Marikina, Pasig, Makati, Taguig and Muntinlupa. Nelson et al. (2000) estimated a recurrence interval of the Marikina West Valley Fault (MWVF) to be between 400 to 600 yrs. Using the fault length-magnitude relationship by Wells and Coppersmith (1994), the fault has a potential to generate an earthquake up to moment magnitude of M_w 7.5.

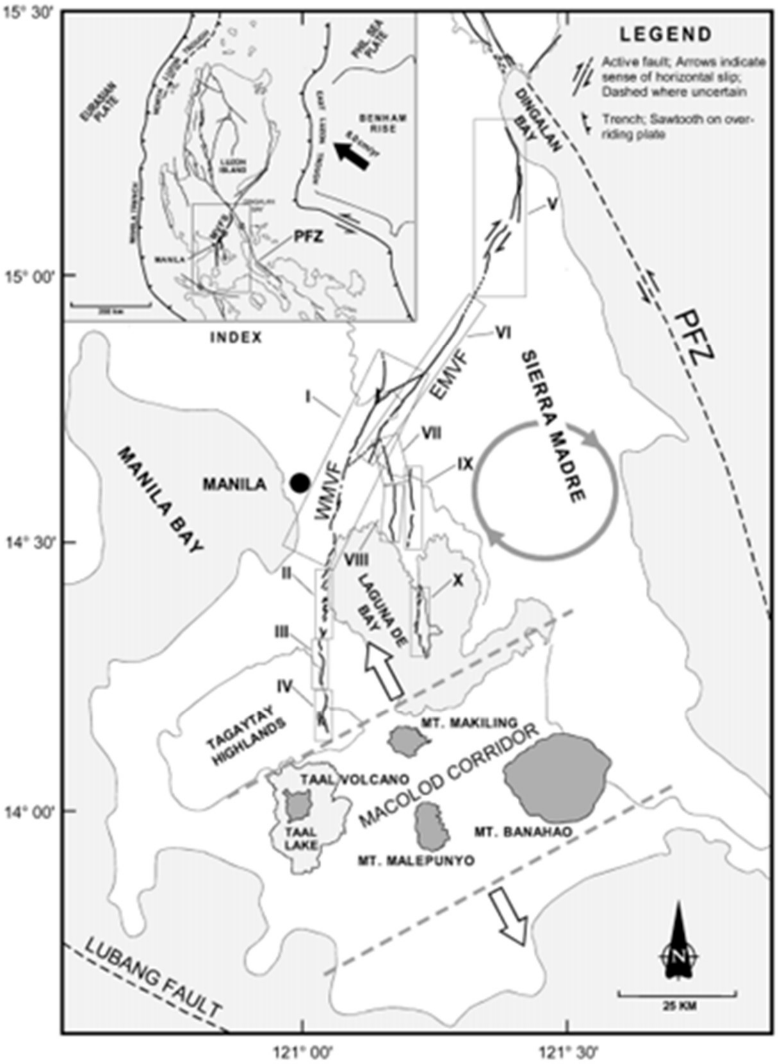

Figure 7. Map of main tectonic elements in central Luzon related to the Marikina Valley Fault System. The MVFS branches from the PFZ while both its segments, East and West Marikina Valley Fault (EMVF and WMVF, respectively) appear to terminate near the rifting front of Macolod Corridor. Roman numerals refer to the structural/geometric segments of the fault system identified by Rimando et al. (2006).

Another potential earthquake generator in the vicinity of the study area is the Lubao Fault in Pampanga (Fig. 8). It was first named Lubao Lineament by Siringan and Rodolfo (2003) as the northeast trending lineament located northeast of Natib Volcano that separates the alluvial fans of Mt. Pinatubo and Natib from the low-lying coastal wetlands of northwest

Manila Bay. Soria (2009, in Lagmay et al., 2012) reported a 3.5 m vertical component of lineament motion over the past 1500 yrs using data from paleosea-level reconstructions and scatter interferometry of the Lubao area. From these data, Lagmay et al. (2012) interpreted this structure as the Lubao Fault. This NE-trending fault has a total length of approximately 73 km and has the potential of generating an earthquake up to M_w 7.2.

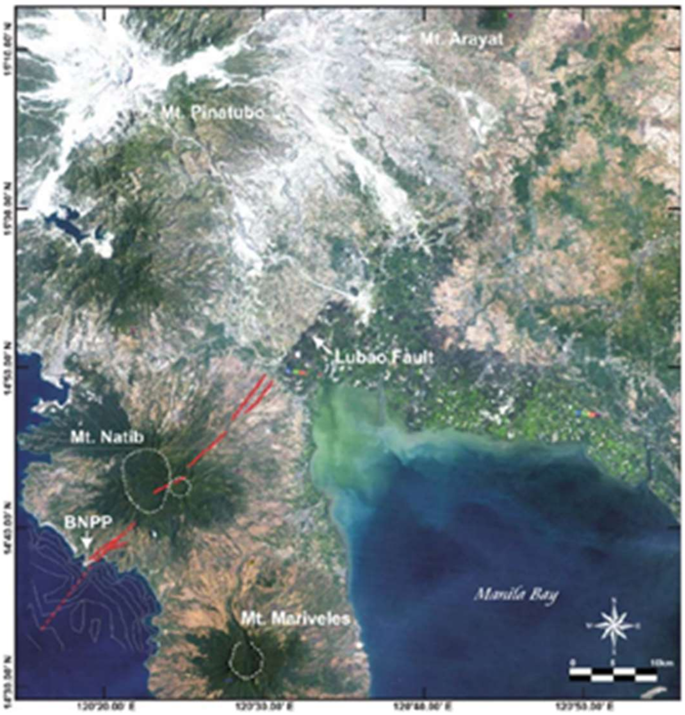

Figure 8. Lineament interpretation and trace of Lubao Fault in the vicinity of Mt. Natib from satellite interpretation of Lagmay et al. (2012).

One more possible source of earthquake events in the vicinity is the offshore Manila Trench subduction system (Fig. 1). It is the trench system that accommodates the convergence of the Luzon Arc and the South China Sea Basin and therefore is tectonically and seismically active. The trench system starts south from about 13° N near northern Mindoro and trends in an almost straight line up to 18° N. At around 20° N, it forms a wide bend before continuing to Taiwan (Bautista et al. 2001). This poses a significant risk to the vicinity of Manila Bay, for this structure has a history of producing strong offshore earthquakes and tsunamis.

Geomorphology

Manila Bay is a 1,800 km^2 body of water in western Luzon Island (Fig. 9; EMB, 1992 in Siringan and Ringor, 1997). It is bounded by the Bataan Peninsula to the west, the

Pampanga delta to the north, and the shorelines of Manila and Cavite to the east and south. It opens up to the South China Sea basin through two channels divided by the Corregidor and Caballo Islands (Siringan and Ringor, 1997). The coastline varies from the highly embayed rocky shores of Cavite and Bataan to the tidal plains of the Pampanga-Bulacan area. Longshore currents in the southern part of the bay led to the formation of sand spits (e.g., Cavite Spit) and contributed to the formation of beach and chenier ridges in the Bulacan-Manila area (Siringan and Ringor, 1997; Soria et al., 2005). Some lineaments affect the northwest coast, with the most prominent lineament traversing northeastwards through Hermos, Bataan to Bacolor, Pampanga causing vertical movements (Siringan and Rodolfo, 2003; Soria et al., 2005) (Fig. 9).

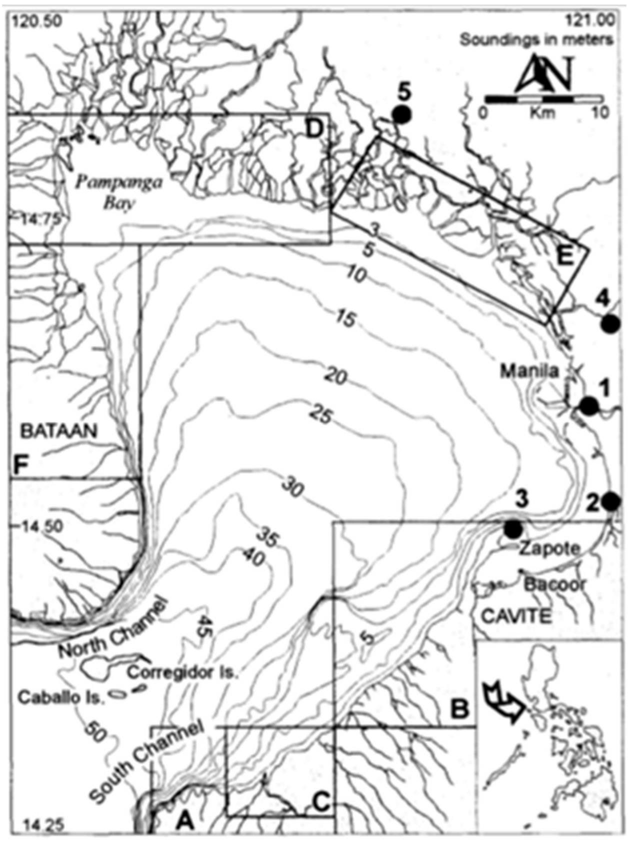

Figure 9. General geomorphology and bathymetry of Manila Bay (Siringan and Ringor, 1997).

A total of 26 river systems drain into the Manila Bay (Fig. 9), with the Pampanga-Angat and the Pasig-Marikina-Laguna de Bay systems contributing the majority of the discharge (Siringan and Ringor, 1997). Rivers in the southern part of the bay form wave-dominated deltas, while the large Pampanga delta complex in the north displays both tidal and wave influences.

The Pampanga delta serves as the southernmost part of the broad plains of the Central Luzon Valley (Fig. 10). Most of the sediments originate from the two mountain systems that bound the valley, the Sierra Madre range in the east, and the Zambales-Bataan (i.e., Pinatubo, Natib, Mariveles) range to the west. The 2,700 km^2 delta is characterized by multiple anastomosing tidal channels that serve as the distributaries of the rivers that drain into the delta, e.g., Pampanga, Angat, Bulacan, Pasac (Siringan and Rodolfo, 2003). In between the distributaries are very gently sloping tidal flats, such that some parts of the delta exhibit elevations of 10 masl more than 20 km from the shore (Siringan and Ringor, 1997; Soria et al., 2005). Brgy. Taliptip, Bulakan is built atop these gently sloping tidal flats (Fig. 10).

Figure 10. Geomorphological regions (bounded by yellow lines) around the northern part of Manila Bay. Drainage network data (pale blue) taken from the OpenStreetMap project. Major rivers (blue) based on list by DENR-MBCO and NAMRIA (2015) Town locations are indicated. Location of Brgy. Taliptip is marked with a red dot.

Climate and rainfall

Under the Köppen–Geiger system, Bulakan falls under the Aw (tropical savannah) and Am (tropical monsoon) classes (Beck et al., 2018). The Philippine Atmospheric

Geophysical and Astronomical Services Administration's (PAGASA) modified Corona's climate classification scheme places Bulakan under the Type I climate. Type I has a dry season running from November to April and wet season throughout the rest of the year (Coronas, 1920, Kintanar, 1984). Temperatures have a mean of 27-28 °C with maximum temperatures in April (~30 °C) and minimums in January (~26 °C) (Fig. 11).

The climate of Manila is typical of the western Pacific islands in the southwest monsoon belt, with annual rainfall at 2574 mm (Science Garden, Fig. 11). The southwest monsoon takes effect from late June to August, delivering most of the rainfall of the year, with a peak of 504.2 mm in August at the nearby rain gauge in Quezon City (Fig. 11).

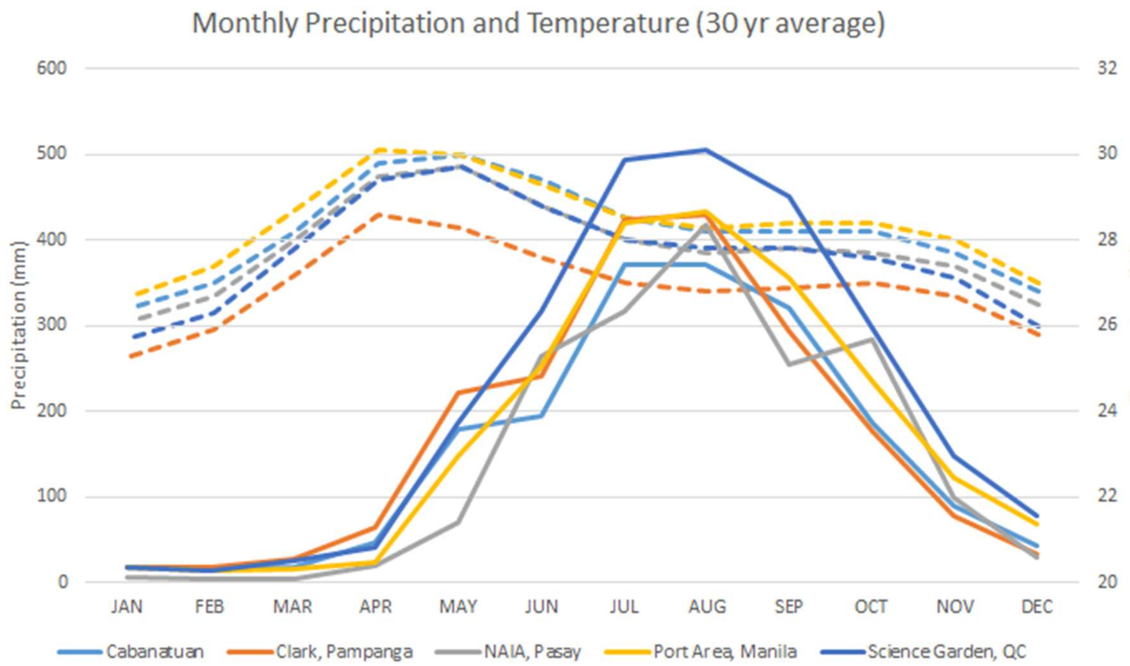

Figure 11. 30 yr averages for mean precipitation (solid) and mean temperature (dashed) taken from 5 weather stations close to Brgy. Taliptip. (PAG-ASA, 2018).

Natural Hazards

Seismic hazards

The Manila Bay, whose general vicinity is surrounded by several potential earthquake generators, is well exposed to its associated seismic hazards. Historical earthquake catalogs indicate that Manila has experienced several devastating earthquakes in its recorded past (Table 1). Seismic hazards associated with these events include surface rupture, ground shaking, tsunami, and liquefaction.

Table 1. Historical earthquakes that affected Metro Manila and environs. Data is from the work of Garcia et al. (1985).

Date	Location	Magnitude	Depth (km)	Other Notes
Aug. 19, 1658	14.650 N, 121.100 E	5.7	28	Intensity X in Manila, with heavy damages. Several churches underwent total destruction. Damages also reported in Antipolo. Several people died and some were injured due to falling ruins.
Feb. 01, 1771	14.550 N, 121.150 E	5.0	13	Damages concentrated in Ermita, Manila. Church in Antipolo sustained damage.
June 03, 1863	14.450 N, 120.900 E	6.5	15	Destructive earthquake, destroying many structures in the city. Many cathedrals, churches, and other buildings were left in total ruins. Shaking was felt in other provinces such as Bulacan, Cavite, Pampanga, La Union, and Nueva Ecija. Tsunamigenic as well.
Oct. 01, 1869	14.250 E, 120.450 N	6.6	50	Several damages in Manila's churches and buildings. Damages from shaking reached up to Cavite, Pampanga, Zambales, and Bataan. No casualties recorded, but several incurred minor injuries.
Dec. 29, 1872	14.400 E, 120.350 N	6.4	50	Shaking felt throughout northern Luzon. Felt in Bulacan, Pangasinan, Batangas, Zambales, Bataan, Nueva Ecija, Aurora, and Camarines Norte.
Mar. 28. 1940	14.200 N, 120.600 E	6.8	160	Intensity IV to V in Manila, Batangas, and Mindoro. Intensity V in Capas, Tarlac and Iba, Zambales.

July 19, 1956	15.100 N, 120.500 E	5.7	33	Intensity VI in Iba, Zambales. Intensity IV in Manila, Dagupan, and Baguio.
Sept. 19, 1968	14.920 N, 120.240 E	5.2	60	-
Apr. 25, 1972	14.200 N, 120.300 E	5.3	33	Intensity V in Manila, Cavite, Ambulong, and Tayabas. Intensity IV in Cabanatuan, Cuyo, Coron, and Iba. City library of Manila was heavily damaged, as well as several buildings along Escolta and Espana.
June 16, 1991	15.050 N, 120.320 E	5.1	24	-

Paleoseismic trenching studies conducted on the MVFS indicated at least two large surface-rupturing events have occurred since AD 600, hence the recurrence interval of 400 to 600 yrs (Nelson et al., 2000). Bautista and Oike (2000) suggested 1658 and 1771 earthquakes as the likely candidate events that produced the rupture of the Markina East Valley Fault (MEVF). Historical accounts indicate that the 20 August 1658 (estimated M_s 5.7) affected Manila, southern Luzon, and other neighboring provinces. Most accounts detail the destruction of several stone churches and other buildings, as well as injuries related to falling ruins. The 01 February 1771 event (estimated M_s 5.0) occurred at night and was described as a "violent earthquake" and had an observed maximum intensity of IX. Damage was specifically concentrated in Manila, principally reported in Ermita, ruining several churches (Garcia et al., 1985). However, no recorded event can be associated with the movement of the MVFS. This poses a serious threat in the vicinity as a major event might occur in the near future to release the accumulated stress along the fault.

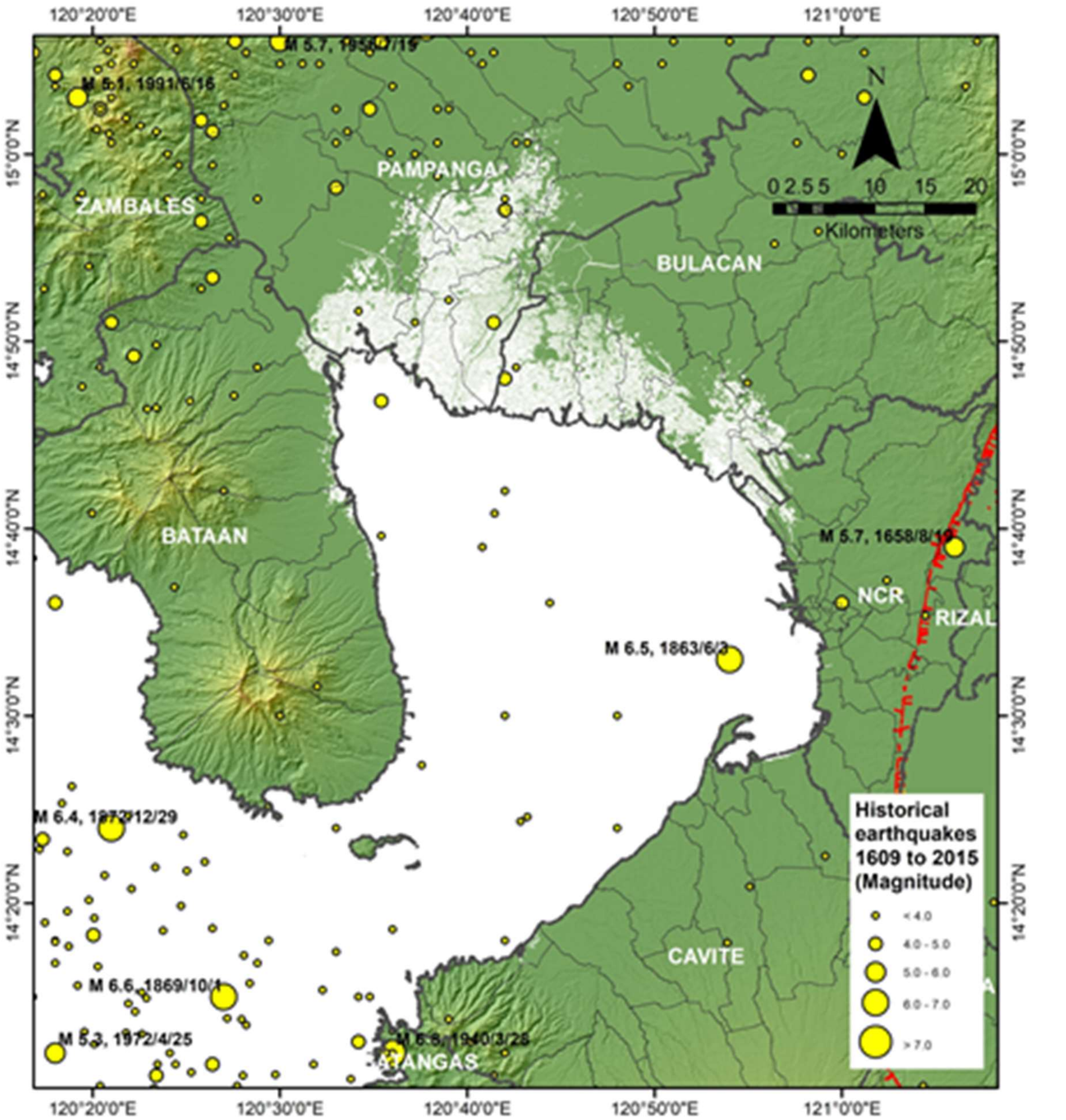

Figure 12. Magnitude and epicenters of historical earthquakes in the vicinity of Manila Bay from 1609 to 2015. InSAR relief map generated by O. Halasan.

However, perhaps the strongest earthquake event that struck Manila in recorded history is the 3 June 1863 earthquake with an estimated magnitude of M_s 6.5 and a maximum observed intensity of X on the Modified Mercalli intensity scale. Churches, cathedrals, and other structures were almost partially or completely levelled to the ground. In Manila Bay, a large wave coming from southeast going northwest was also documented. It struck forcefully on several boats that it came over the decks and toppled others. Water also appeared to be “boiling with strong convulsion and whitish color” (Garcia et al., 1985). This account could be the only record of tsunami event on the Manila Bay. Fissures and ground openings emitting gases, water, and dirt were also reported in multiple locations. Damage produced by the quake was so extensive that other provinces, i.e., Cavite, Rizal, Bulacan, and Pampanga, experienced significant damage. Ground shaking was also reported as far as Mindoro, Laguna, and Camarines.

Subsidence

Subsidence is a form of mass movement which occurs in two ways:(1) cavity collapse where a slab of rock or an amount of soil drops into a void as in karst terrains; and (2) settlement where the surface is gradually lowered due to naturally compacting sediments from extraction of groundwater or seismic movement (Hugget, 2007).

Delta sequences are mostly made of water-retarding mud layers with minor sand or gravel which serve as aquifers or water-bearing layers (Rodolfo et al., 2003; Soria et al., 2005). Groundwater withdrawal generally takes away the water from aquifers and the extracted resource is replenished by percolating rainwaters (Rodolfo et al., 2003). Over-extraction of groundwater often leads to irreversible thinning of coastal mud deposits due to dewatering to fill the voids which lack pressure within aquifers (Rodolfo and Siringan, 2006). Unfortunately, the watersheds in the upstream portions of northern Manila Bay area are too small to store enough water for the dry seasons, leading to the progressively aggravating groundwater mining by lowland residents and industries every year (Siringan and Rodolfo, 2003; Soria et al., 2005; Rodolfo and Siringan, 2006).

Using SAR interferometry, Raucoles and others (2013) showed that the Manila urban area has been subject to vertical ground deformation by up to 15 cm/yr with temporal and spatial variability from 1993 to 2010. Similar work by Eco (2011, in Van't Veld, 2015) indicates subsidence in excess of 4.5 cm/yr (Fig. 13). It is important to note that the natural compaction rate calculated from dating organic remnants in sediment cores from the study area is about 0.2 to 0.6 cm/yr, almost similar to the global rates as in Po Delta, Italy and Mississippi Delta, USA (Soria et al., 2005). Thus, previous studies claim that subsidence is approximately 98% (Soria et al., 2005) due to the constant excessive withdrawal of groundwater and ground motion along the nearby fault systems; although the origin of ground motion may either be tectonic or still related to the water extraction (Rodolfo et al., 2003; Siringan and Rodolfo 2003; Soria et al., 2005; Rodolfo and Siringan, 2006; Raucoles et al. 2013). Such practice is attributed to agriculture, aquaculture, and the rapid growth of population in the metropolis (Rodolfo et al., 2003; Rodolfo and Siringan 2006). Continuous over-extraction is bound to cause depletion of groundwater or contamination through saltwater intrusion, which makes the resource unsafe for usage (Rodolfo et al., 2003).

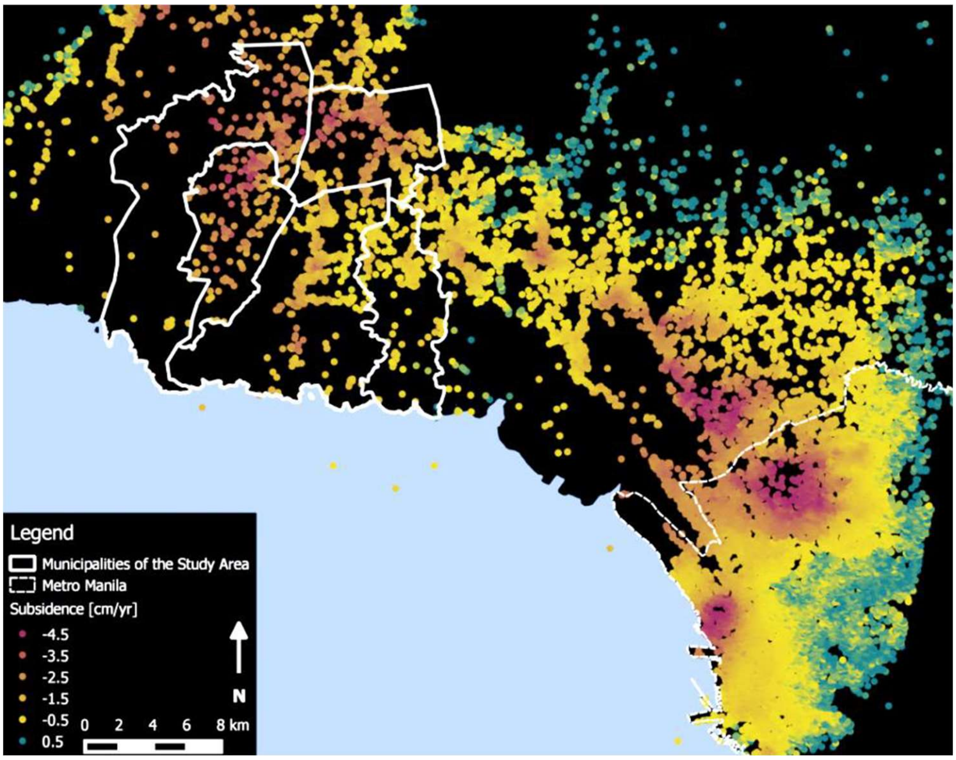

Figure 13. Annual subsidence rate of the northeast Manila Bay area as determined from PSInSAR (Eco, 2011 in Van't Veld, 2015).

Measured subsidence rates have not varied from the period before the 1991 Pinatubo eruption and during the time of their study (Siringan and Rodolfo, 2003). Surveys using deep wells in Lubao, Pampanga and in the lowland towns of Bulacan yield an average surface lowering rate of 2.5 cm/yr (Siringan and Rodolfo 2003, Rodolfo and Siringan, 2006). Meanwhile, sediment cores from coastal barangays in Bocaue, Malolos, Bulacan and Lubao, Pampanga exhibit shoaling upward sequences wherein the subsidence rate of near-surface sediments show 2 to 8 cm/yr; moreover, natural compaction only accounts for 2 to 8% of these measured rates (Soria et al., 2005). Sociological data taken from the accounts of several locals commonly indicate worsening tidal floods in coastal barangays, and this is backed up with the geodetic surveys by the DPWH (2001) along benchmarks which have been established since the 1950s (Rodolfo et al., 2003). Other critical scenarios include increasing road elevations by 0.5 m/yr in Batang Segundo, Lubao, Pampanga due to local flooding (Siringan and Rodolfo, 2003).

Scientists persistently emphasize the need to curtail groundwater withdrawal and for proper utilization of system resources to lessen the impacts of subsidence and flooding in the Manila metropolitan area and the Central Luzon lowlands (Rodolfo et al., 2003; Siringan and Rodolfo, 2003; Soria et al., 2005; Rodolfo and Siringan, 2006).

Storm surge and flooding

On the northern side of Manila Bay, where the Pampanga and Angat River Deltas are located, coastal municipalities are frequently confronted with fluvial and tidal floods. Fluvial floods are usually caused by typhoons and the rains brought by the southwest monsoon. The tidal floods, however are caused by storm surges and high tides. Tidal floods are less worrisome compared to the fluvial floods due to the fact that they only make some roads near the shore inaccessible and flood a few houses. Meanwhile, fluvial floods affect a larger area, damaging farms and fishponds, as well making roads inaccessible and flooding municipalities (Van’t Veld, 2015).

The areas surrounding Northern Manila Bay are generally flat and have very low elevation. They are very much at risk of flooding when exposed to continuous rain which promotes fluvial floods (Fig. 14A) as well as storms that can cause storm surges (Fig. 14B). Sea-level rise due to local subsidence is also a problem. Unorganized urbanization and excessive withdrawal of groundwater in the area promote subsidence and increases the risk of flooding (Siringan and Rodolfo, 2003)

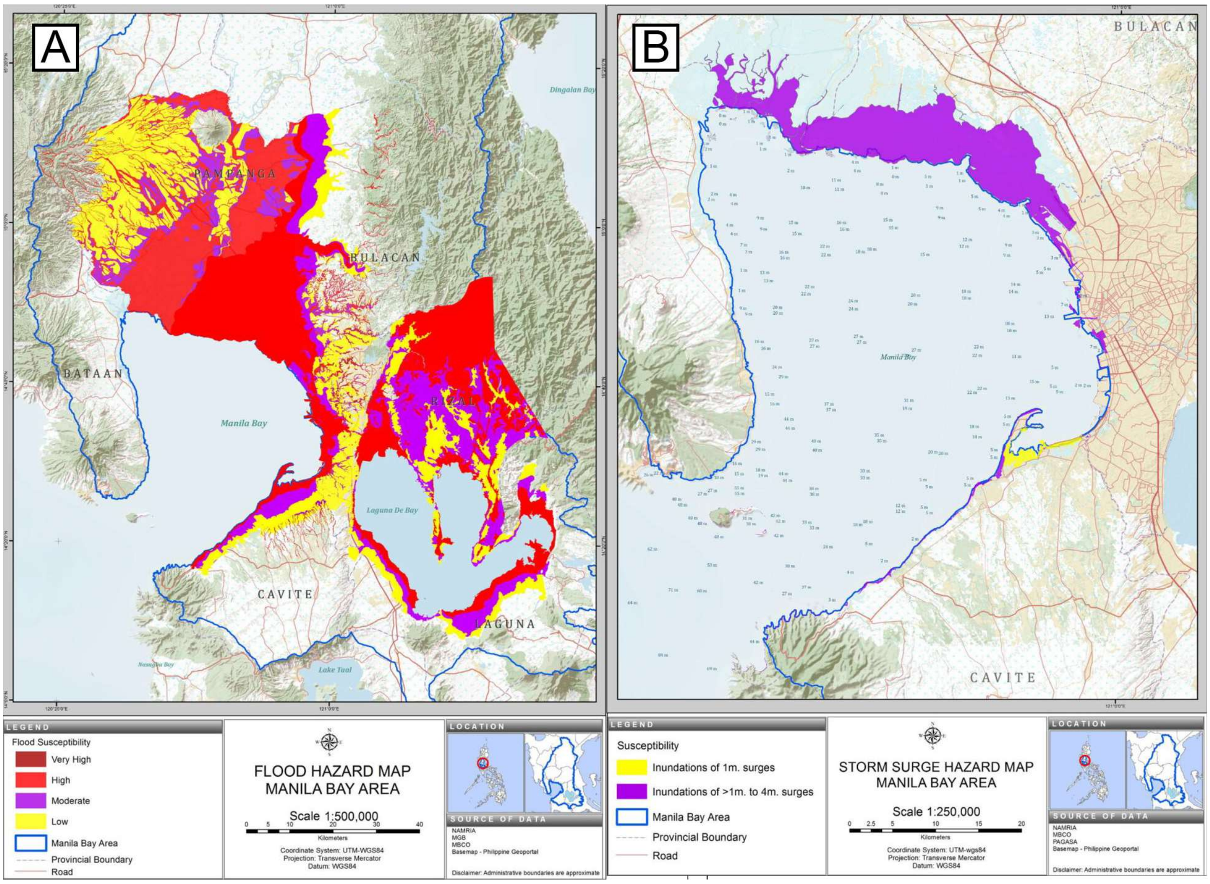

Figure 14. A. Flood hazard map of the Manila Bay and Laguna de Bay. **B.** Storm surge hazard map of Manila Bay (DENR-MBCO and NAMRIA, 2015).

Results and discussions

Hazard Assessment

A variety of geohazards were identified and assessed in seven sitios of Brgy. Taliptip, Bulakan, Bulacan. Locals were asked to recount their experiences on earthquake, storm surge, fluvial and tidal flooding, and land subsidence events. Majority of the interviewees repeatedly experienced fluvial and tidal flooding, and storm surges, characteristic of communities situated in coastal areas. Occasionally, the effects of earthquakes were also felt. Subsidence was not reported, probably because of more visible and abrupt effects of tides and storm surges on land elevation.

Earthquake

The two frequently mentioned events in the locals’ accounts are the 1990 M_w 7.7 Luzon Earthquake and the 2019 M_w 6.1 Zambales Earthquake, both of which were also felt in nearby provinces. Some recalled their experiences of the 1968 M_w 7.6 Casiguran Earthquake.

The 1990 M_w 7.7 Luzon Earthquake was generally felt in Brgy. Taliptip with Intensity V, based on the Phivolcs Earthquake Intensity Scale. Some areas sustained considerable damage, leaving houses with cracks and some fishpond dikes and breakwater structures in Sitio Pariahan irreparable. One respondent narrated how they stayed up all night after the earthquake in fear of strong aftershocks.

The 2019 M_w 6.1 Zambales Earthquake was reported to have intensities ranging from III to V. This is characterized by toppling of objects from shelves, tilting of bamboos and logs used as foundation of houses, and shaking of the ground causing nausea. Damage to structures is limited to cracks in some concrete houses. No casualties or injuries were reported. Reports of the duration of the shaking were varied, while most described the strong tremor lasting only seconds; some stated that weak, albeit perceptible ground shaking persisted for a few minutes to over 30 minutes.

Main hazards associated with large-magnitude earthquakes which could affect Brgy. Taliptip include ground ruptures, liquefaction, coseismic uplift, and lateral spreads. The 1964 M_w 9.2 Alaska Earthquake caused widespread liquefaction and lateral spreads along the shoreline of Alaska.

Tide

The average monthly tidal data in Manila Bay for low and high tide is about -0.21 m and 1.26 m, respectively (Mobile Geographics, 2019; Fig. 15). Semidiurnal tidal cycle, with two high tides and two low tides, usually occurs in Manila Bay. The average duration of the tide lasts for 6 to 9 hrs.

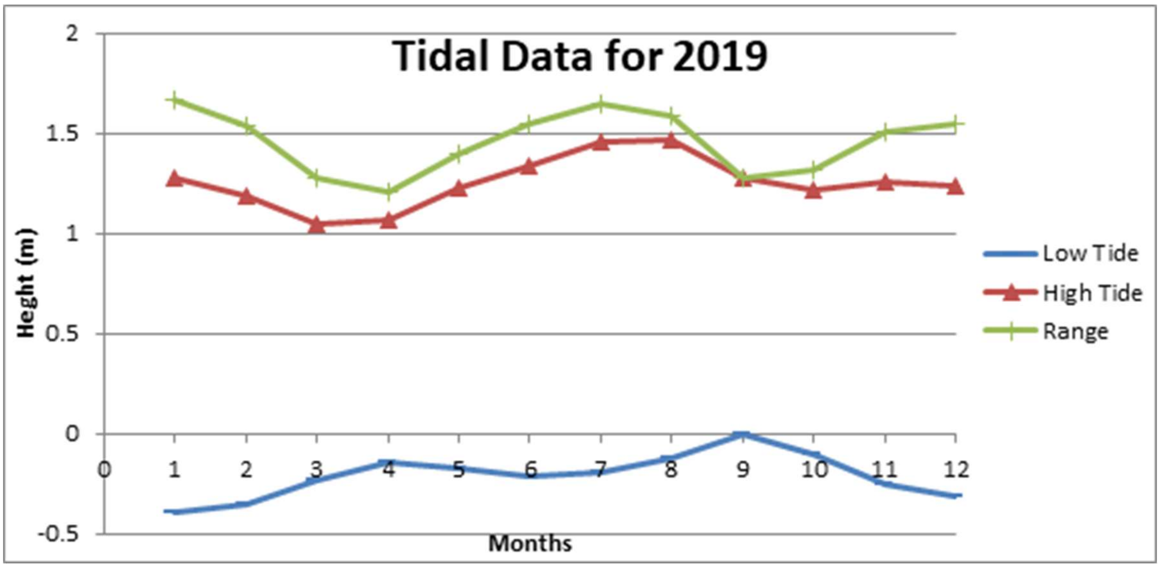

Figure 15. Predicted minimum low tide and maximum high tide data obtained from Mobile Geographics (2019).

The residents of Brgy. Taliptip utilize the available tidal data in their calendars (Fig. 16). Activities such as fishing, travelling and *pangangapa* (the act of groping shrimp, crabs and fish) are dictated by the tide. If a storm occurs at the same time with the high tide, the cumulative effect of waves and tidal rise will result to more severe flooding and increases the risk due to flooding.

Figure 16. Sample of a calendar showing estimated local tidal times and heights that serves as a guide for their fishing and transportation activities.

Storm surge

Storm surges strongly affect the sitios located at the coastal frontier, namely: Kinse, Dapdap, Pariahan, and Camansi. The sitios situated more inland and distal from the open sea (Bunutan, Capiz, and Capol) still experience storm surges but of lesser intensities. The most notable events are the 2018 SW monsoon (*Habagat*) rains, 2011 Typhoon Nesat (Pedring), and 2013 Super Typhoon Haiyan (Yolanda).

On August - September 2018, the SW monsoon (*Habagat*) brought heavy rains and strong winds, damaging the coastal communities of Brgy. Taliptip. Locals noted several surges that lasted from 1-2 hrs, with surge heights varying throughout the different sitios. The maximum surge height estimated at Sitio Kinse was around 4 m, while in Sitios Dapdap, Bunutan, and Capol was about 2.5 m, 1 m, and 0.5 m, respectively.

The August-September 2018 *Habagat* consists of a series of surges with entrained debris (e.g., logs, bamboos, garbage) which wreaked havoc on properties that rendered some concrete houses uninhabitable. The houses made of light materials were easily eroded, with the foundations, walls, and roofs carried by strong water flow. For this event, an inundation distance of five meters was noted in Sitio Kinse. The onset of low tide caused the retreat of water back to the open sea and river. The issuance of Public Storm Signal #3 prompted the immediate action of the barangay officials to evacuate the residents, leaving no casualties.

The 2011 Typhoon Nesat (Pedring) was vividly remembered by the community for the damage it caused. Fishpond dikes and mangrove areas were destroyed by the onslaught of the storm. A number of houses were swept by the surges. In Sitio Pariahan, the entire community was left in ruins, leaving only four out of the forty houses intact. One respondent detailed how on the morning of September 27, the residents attempted to evacuate to higher ground at a nearby grain silo but were immediately hindered by the strong winds and waves. From 08:00 AM to 04:00 PM, the residents needed to cling for survival to the stilts of makeshift fishpens, nearby trees, or anything that stood amidst the storm. Maximum surge heights of 4 m, 4 m, 3 m, and 1.5 m were estimated in sitios Pariahan, Kinse, Capiz, and Camansi, respectively.

During Super Typhoon Haiyan (Yolanda) in November 2013, sitios Dapdap and Camansi recalled some natural and man-made levees being submerged. The 2008 Typhoon Fengshen (Frank) brought 3-m high surges that devastated some houses in Sitio Capiz, as recounted by a respondent.

Given the mean occurrence of about 20 cyclones per annum entering the Philippine Area of Responsibility (David et al., 2013), there is a high probability to generate storm surges. Despite this, the coastal communities survive in part due to the presence of mangrove tracts that serve as a natural barrier from storm surges and strong waves.

J. Mendoza and J. Santiago of the University of the Philippines Resilience Institute (UPRI) generated storm surge hazard maps for the different Storm Surge Advisories (SSA) (Fig. 17). The advisories are based on the modeled maximum surge heights, with SSA 1 indicating 2-m high surges, and SSA 2, 3, and 4, showing 3-m, 4-m, and 5-m high surges, respectively. When the data gathered from the survey was juxtaposed to these maps, it appears that the field data was consistent with the model.

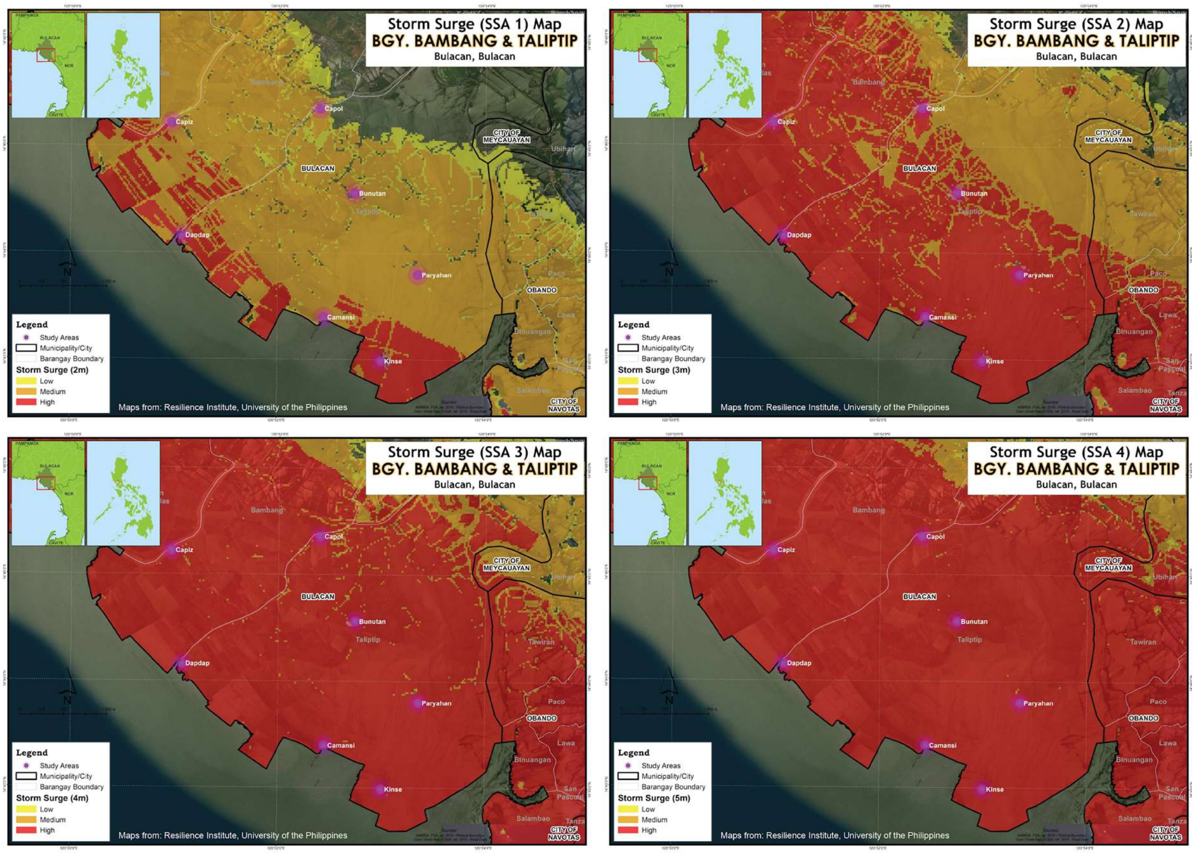

Figure 17. Storm surge hazard maps showing the probability of inundation by storm surges in the coastal communities of Bulakan, Bulacan, with the different Storm Surge Advisories. The sitios of Brgy. Taliptip are shown as purple dots. Increasing probability is shown from yellow to orange to red. Storm surge modelling conducted by J. Mendoza and J. Santiago.

River flooding

The communities of Brgy. Taliptip have experienced two types of flooding based on origin: tidal and fluvial flooding. The former is influenced mainly by localized high tide which is affected by various factors such as the lunar cycle, coastal topography, and bathymetry. The latter is more closely associated with overflow of river channels and breaching of natural levees from the sudden input of water from upstream drainage. However, based on local accounts of flooding, it is difficult to separate the two types, and the resulting flood heights are likely results of the combination of both processes.

Sitios sitting on channel levees proximal to the fluvial channels experience short-duration floods because runoff readily drains into these waterways and back to the open sea when the tide starts to fall. This is in contrast to sitios adjacent to fishponds bounded by dikes, they experienced prolonged elevated water levels. In Sitio Bunutan, a 1-m high flood, measured from the pavement, lasted for 1-2 wks. A similar incident was reported in Sitio Capol, in which a 0.2-m flood persisted for two weeks.

Respondents linked these floodings to three factors: release of water from dams upstream, heavy rainfall brought by typhoons or monsoons, and simultaneous high tides. According to the interviewees, the communities are normally warned by barangay officials if Ipo Dam and/or Angat Dam will be releasing water. Likewise, if an incoming storm or monsoon would bring substantial precipitation, the communities would be alerted and advised to evacuate. More devastating floods were reported to coincide with high tide (colloquially termed "*paglaki ng tubig*") which would lead to a higher water level.

Subsidence

Subsidence in the area of Brgy. Taliptip were not observed by the local residents. However, previous studies (e.g., Rodolfo et al., 2003; Soria et al., 2005; Rodolfo and Siringan, 2006; Eco, 2011; Raucoles et al., 2013) have identified areas of subsidence along the Manila Bay coast from Bataan to Manila. The likelihood of occurrence in Brgy. Taliptip is high, because it is part of the Pampanga delta system. Subsidence occurs normally in deltas due to natural compaction of sediments, although rapid groundwater extraction exacerbates this phenomenon.

Community profile

Barangay Taliptip (Fig. 18) is located at the southernmost end of the municipality of Bulakan adjacent to Manila Bay and bounded to the east by the mouth of the Bulacan River which forms part of the broader Pampanga delta. The residents are mostly fisherfolk. Artisan fishing, aquaculture, and agriculture are the primary sources of income.

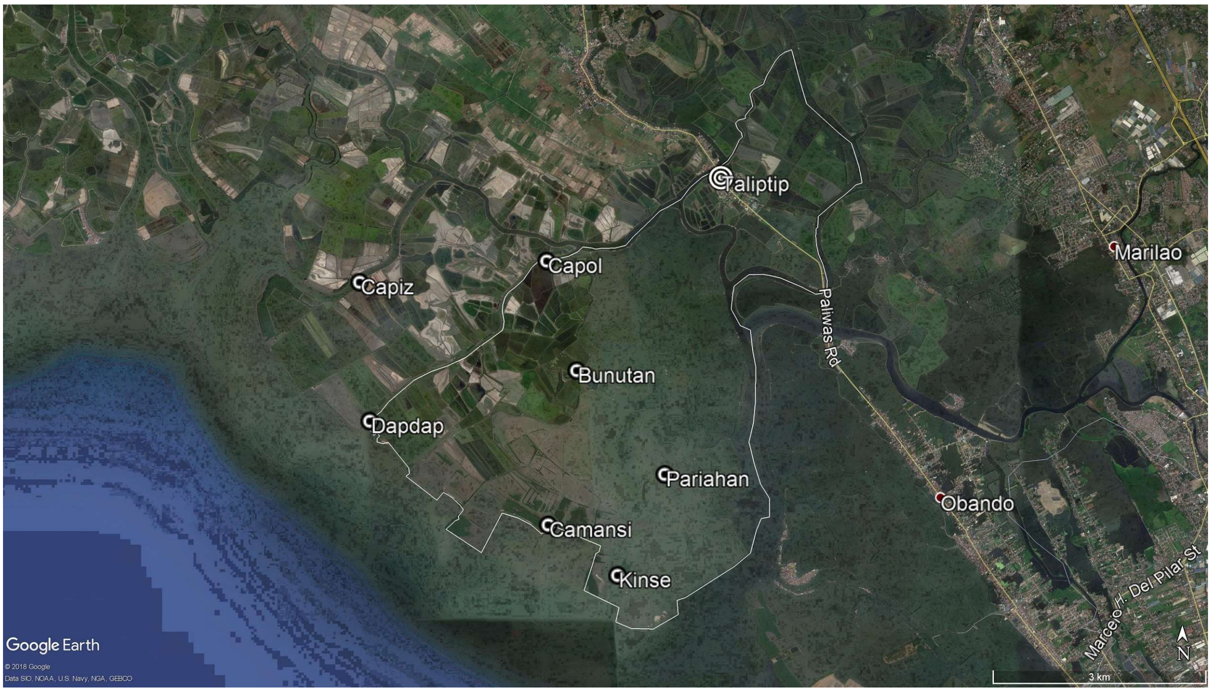

Figure 18. Location of sitios surveyed in Brgy. Taliptip, Bulakan. Taliptip boundary (white line) is based on 2016 PSA data. 2018 satellite imagery from Google Earth.

Seven sitios, namely Bunutan, Camansi, Capiz, Capol, Dapdap, Kinse, and Pariahan (Fig. 18), were surveyed to determine the level of awareness of residents on natural hazards, as well as their sentiments on the Bulacan Aerotropolis project. These sitios are all located on the tidal flats along the coast, which are the affected areas for the planned airport construction. Prior to development, the area hosted wetlands and tidal flats. Historical population growth has led to conversion into fishponds, salt pans, and some agricultural lands. Built-up areas are concentrated along the banks of the distributary channels, which are susceptible to tidal floods. One of the residents recounted that sitios Pariahan and Camansi were formerly built upon dry land that supported agriculture and a thriving community. The 1990 Luzon earthquake breached several dikes which led to a cascade of dike failures, flooding the communities with saltwater to the point that agriculture is rendered impossible.

A total of 35 resource persons were interviewed, with an average of five per sitio (Table 2). Photographs during the interviews can be found in **Appendix 1**. Information obtained in the interview included age, gender, occupation, residence time, type of house construction, experiences with natural hazards, and perception on the anticipated Bulacan Aerotropolis project.

Table 2. Number of respondents for each of the seven sitios of Brgy. Taliptip (Fig. 18).

Sitio	**Number of respondents**
Bunutan	5
Camansi	3
Capiz	7
Capol	7
Dapdap	4
Kinse	6
Pariahan	3
Total	**35**

The targeted resource persons were mostly adults that are commonly the heads of their households and possess a historical perspective of geohazards. Maturity and ability to decide for their families are important criteria. Most (39%) of them belong to the middle-aged group (35-50 yro) (Fig. 19). More females (24) were interviewed compared to males (12), since most males were out working during the day, while most females stay at home to tend to family needs, according to the respondents.

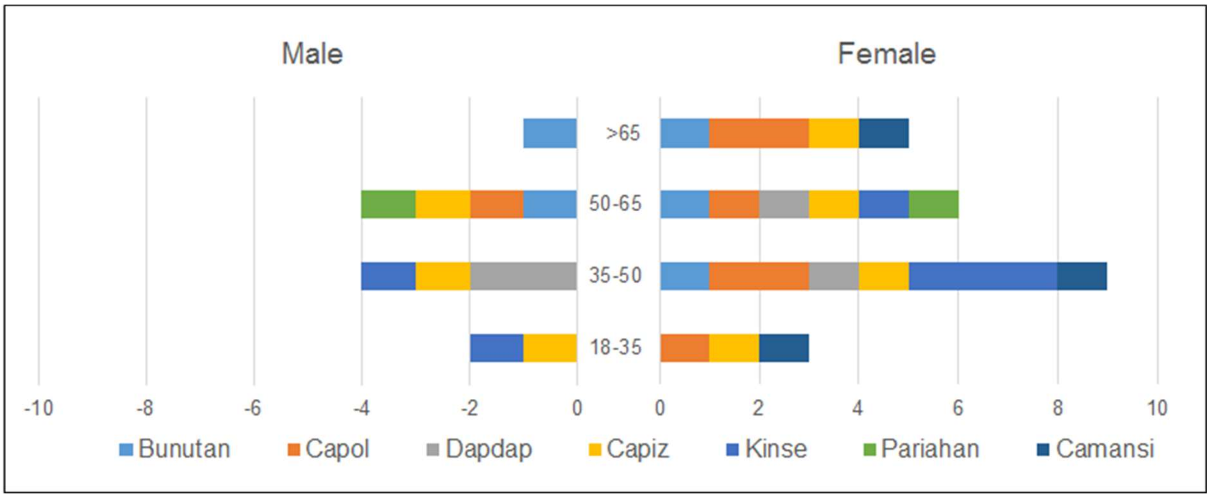

Figure 19. Age-sex distribution graph of the resource persons per sitio.

Residency in Barangay Taliptip ranges from 1 to 63 years, with an average of 32 yrs (Fig. 20). The oldest population of interviewees are migrants from other towns of Bulacan province and the Visayan islands. At least 2 generations have descended from these migrants. Many of those who have short residencies (<5 yr) are employed as caretakers of fish ponds and salt ponds. Thus, many of the interviewed families have established their roots in Brgy. Taliptip.

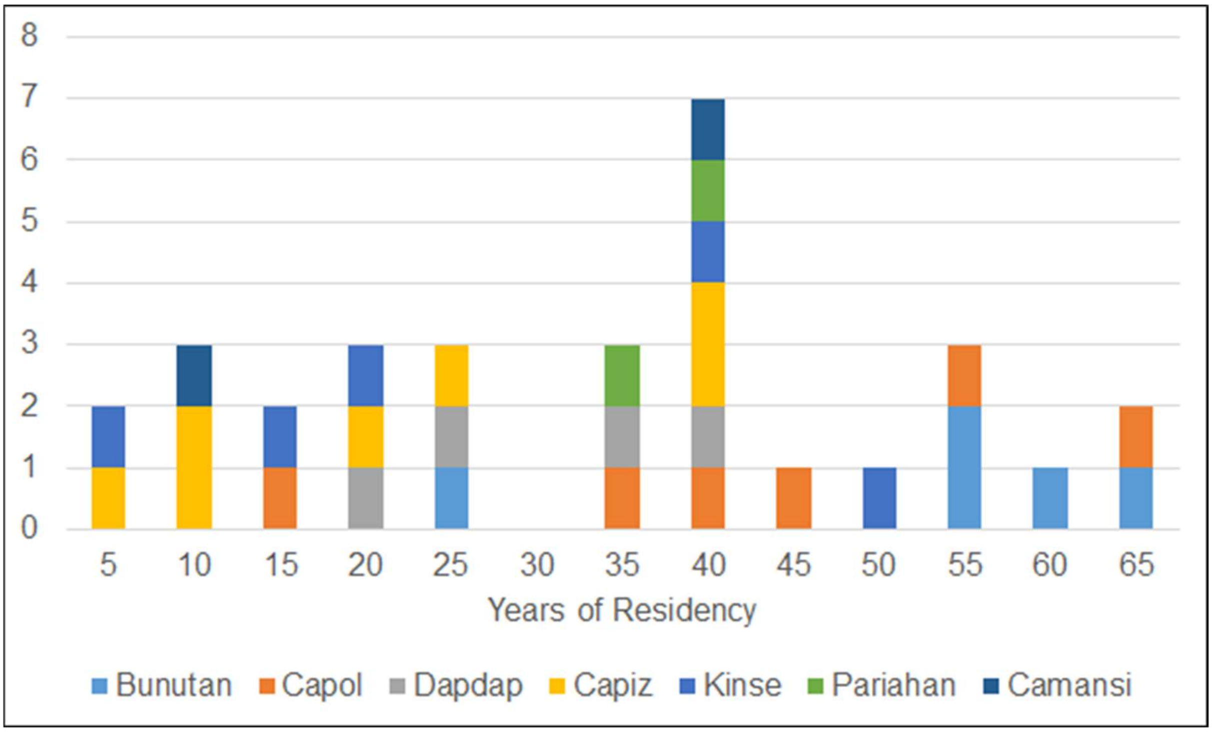

Figure 20. Residency period plot of Barangay Taliptip.

Most people are fisherfolk (23, Fig. 21), reliant on both artisan fishing and aquaculture of both fish and shellfish (Fig. 21). Artisan fishing is promoted through the proliferation of small boats amongst the populace. For aquaculture, Brgy. Taliptip residents are either owners of fish ponds or employees with the owners predominantly from Bulakan town proper. Other sources of income include employment (11) either at the barangay proper or outside of the municipality. A small salt production industry is present, and provides employment for some residents and outsiders. Some residents provide transport services for other residents. A portion of the resource persons are dependent on allowances provided by family members who source income outside of Brgy. Taliptip. Some of the families are recipients of the government’s 4P’s dole. Photographs of these livelihood activities of the residents can be found in Appendix 2.

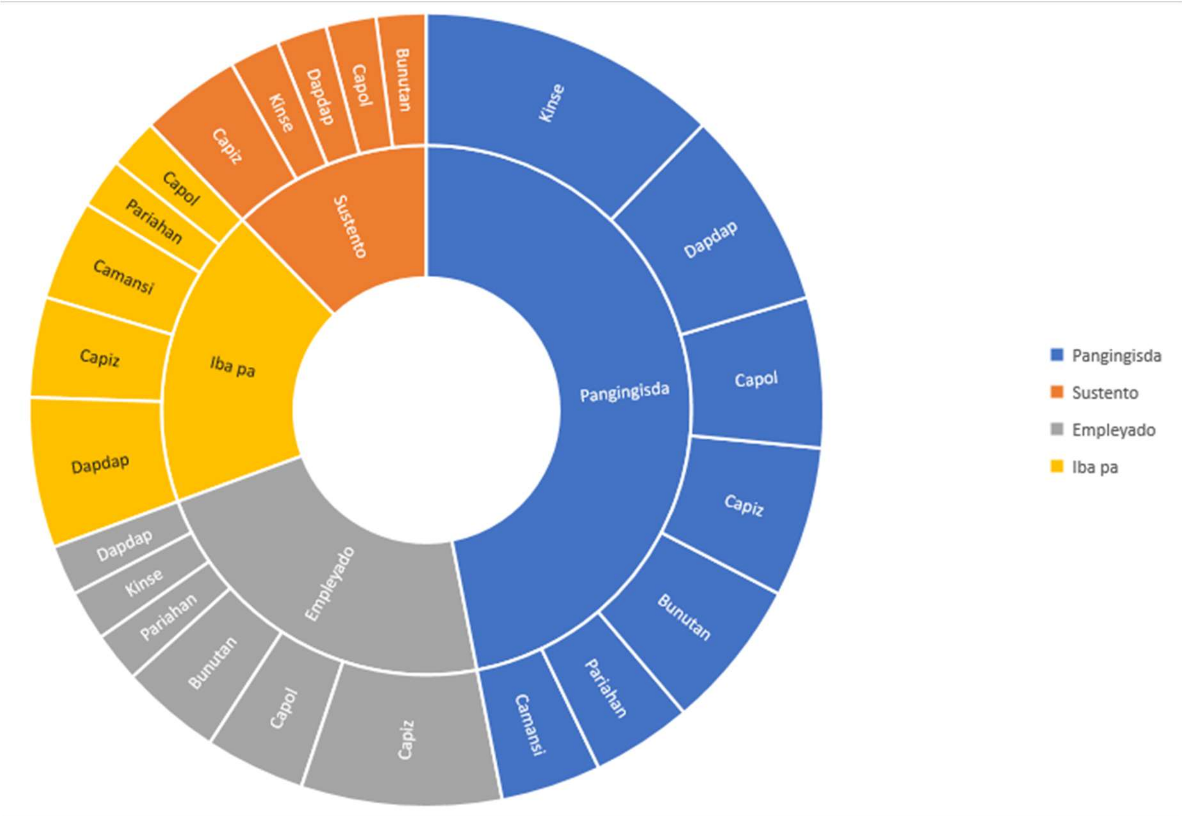

Figure 21. Sources of income for the Brgy. Taliptip respondents per sitio.

Two types of building construction are present; lightweight construction consisting of wood-framed houses with nipa weave (*pawid*) or tarpaulin sheet roofing, and concrete brick houses with galvanized sheet roofs. 19 of the houses are of light construction, while 16 are of concrete brick houses (Fig. 22). Sitios Bunutan and Capol have more concrete brick houses than the other sitios, which could be indicative of economic status. Meanwhile, residents in Dapdap and Kinse prefer to use light materials to facilitate easy reconstruction following storms. In Pariahan and Camansi, the houses are currently built on bamboo stilts along the remnants of concrete structures. Photographs of the living conditions and the community's environment can be found in **Appendix 3**.

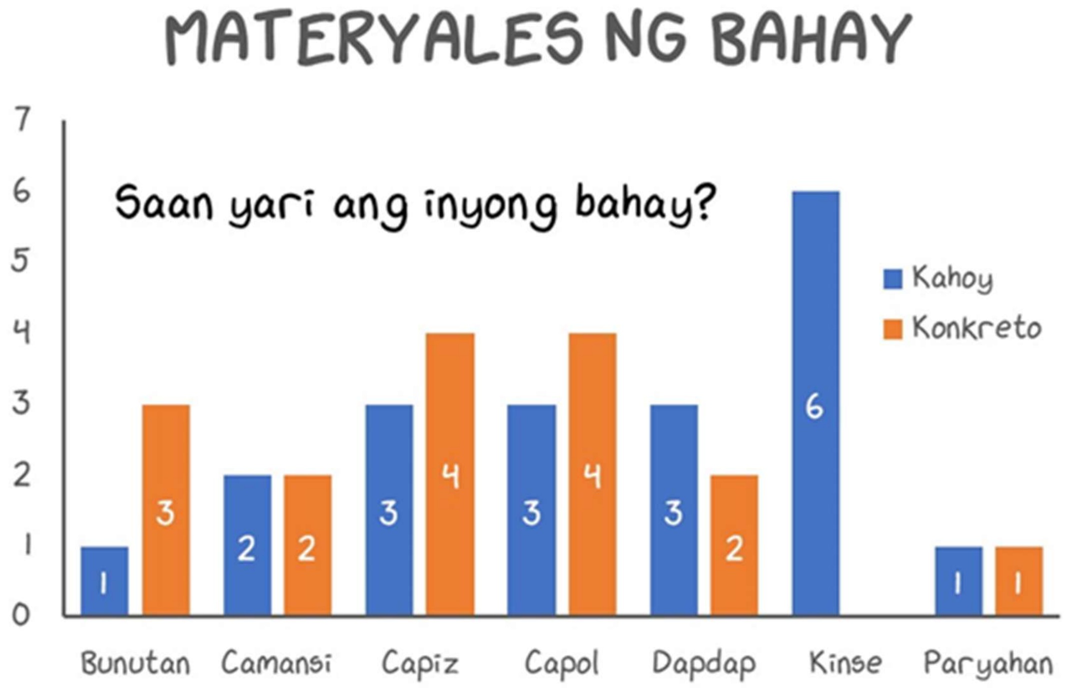

Figure 22. Type of house construction per sitio. *Kahoy* refers to lightweight construction of housing, while *Konkreto* refers to concrete brick houses.

For the duration of the project implementation, there was no available income data from the local government nor from the local people's organization. As such, the house building materials of the residents of Brgy. Taliptip were used as proxy to qualify the family income of the interviewees. Two categories were proposed: those whose houses were mainly built from concrete were qualified as "richer" and those mainly built from wood and scrap materials were considered "poorer". "Richer" respondents were inferred to be more capable of thriving outside of the community than "poorer" respondents.

Most respondents from both categories were not willing to leave their communities and oppose the reclamation activities leading to the construction of the aerotropolis. Most interviewees cite high rent and the prices of goods and services in the cities as reasons for their unwillingness to leave their communities. In fact, some of the resource persons have houses in the barangay centers, located inland compared to the coastal sitios. These residents prefer to stay in the coastal sitios because of their livelihood.

To determine if the kind of their livelihood affects their stance on the airport project, the residents were asked about their sources of income. Four categories were determined: Fishing (*Pangingisda*) – those whose livelihood involve fishing, making nets, setting traps, catching crabs and shrimps, Monetary support (*Sustento*) – those who rely mostly on remittances from their children working abroad or in the nearby cities and 4Ps, Employment (*Empleyado*) – those who are fishpond or salt pond workers and have a steady monthly income, and Others (*Iba pa*) – those who work informally by selling food, running retail (*sari-sari*) stores, providing transport services, and other sources of income. It is clearly shown in Figure 23 that regardless of their livelihood, the majority are opposed to the aerotropolis project.

The residents' livelihood were further classified to reflect where they conduct their work: *inside* the community, *outside* the community, or both (*mixed*). This was to understand if their sentiments on the reclamation activities coincide with how they value the location of their income source. Regardless of where they source their incomes, majority (*inside* – 19 of 24, *outside* – 2 of 2, *mixed* – 9 of 10) resist dislocation, oppose the reclamation of their sitios and the proposed construction of the aerotropolis.

Across age brackets, almost all respondents were against reclamation activities and the Aerotropolis construction and thus, were unwilling to leave their homes (Fig. 23). Those very few who were in favor belong to the lower age brackets. Although few young people expressed willingness to work outside the community, the majority still want to preserve their way of life and depend on the abundant, free, and accessible natural resources of northern Manila Bay. It was also notable that older/senior residents expressed fervent opposition to the project. Some older respondents mentioned that they do not want to be uprooted from their homes and start anew in an unfamiliar place.

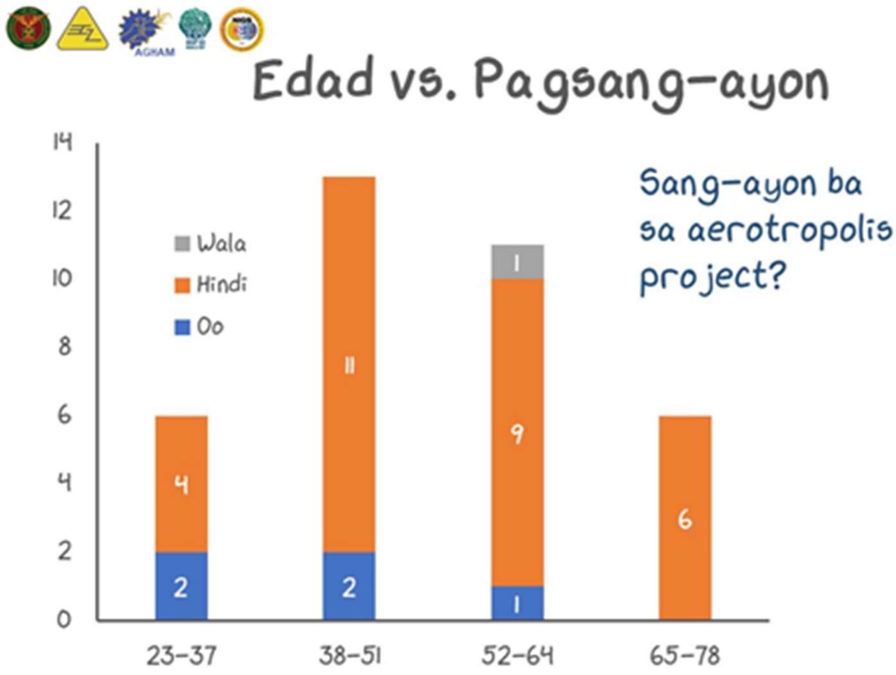

Figure 23. Comparison between the age of respondents and their opinion on aerotropolis construction. *Oo* is affirmative, *Hindi* is negative, and *Wala* is abstain.

Respondents who were against the Aerotropolis Project cite that living in the coastal communities has been a significant part of their personal identity. Many milestones of their lives (birth, marriage, having children and grandchildren) happened in Taliptip. Many interviewees hope to live the rest of their lives and expect their eventual deaths to happen in the coastal communities. If they would be displaced from their communities, many express fears that their relatives and immediate families would be separated because a lot of their sense of belongingness are rooted in the coastal communities. This sentiment is evident when the respondents' years of residence was correlated with their stance towards the Aerotropolis Project. Those who have stayed in Taliptip the longest, 40 or more years, were more unified in their opposition as compared to those with less than 40 yrs of residence.

Vulnerability to hazards and resilience

All sitios in Brgy. Taliptip have experienced different geohazards (earthquake, storm surge, tidal and fluvial flooding) in the past ~60 yrs. Flooding and storm surges are regular events, especially during the rainy seasons, while earthquake experiences are few. Respondents from sitios Bunutan and Capol experienced perennial river-related flooding, while Camansi, Capiz, Dapdap, Kinse, and Pariahan did not report the same since these sitios are closer to the sea and are more subjected to tidal and wave processes.

One major insight from the interviews is the resilience of the residents. Some residents have lived in the area for more than 60 yrs and have never experienced any death nor major injury due to storm surge or flooding events. A local early warning system is in place in which storm advisories are routinely sent through SMS by the barangay captain to the officer-in-charge of each coastal community. In this way, the communities can prepare for evacuation to the mainland before the storm's landfall. In the aftermath of storms and flooding events, destroyed houses and properties are readily rebuilt from storm debris. In the case of Sitio Kinse, where storm events flood or even erode one side of the island, residents rebuild their houses on high stilts and stay for days in their neighbor's houses on the elevated part of the sitio. This is a common and expected practice in Sitio Kinse, which according to residents strengthen the sense of community and belongingness among them. The capability to rise and immediately bounce back to daily routine activities points to a resilient population in the coastal communities.

Food for household consumption is readily available all-year round and respondents put high value on the low cost of living in the sitios. Many attest that seafood is easily caught from nearby waters (artisanal fishing and aquaculture) and only rice and basic commodities are purchased from the town center (meat, only during special occasions).

Residents use solar panels to generate electricity which is then stored in batteries. This is used to power light bulbs, radio, television, fan, and small electronic gadgets such as cell phones, even during the night.

Water for drinking and domestic use comes from water well pumps installed in each sitio. In the case of Camansi and Pariahan, where the original water sources are now below sea level and are reported by residents to be contaminated by seawater, water is bought from the town center or neighboring sitios.

Concerning the threat of displacement due to the construction of the aerotropolis by San Miguel Corporation, the households from the seven communities interviewed were almost unanimously against this reclamation project. Residents cite loss of livelihood, absence of alternative livelihood skills, loss of residence and identity, and high cost of living in the mainland as the main reasons why most of them would choose to stay in the area amidst perennial geohazards. Food like crabs and fish are readily available in the coastal area, which the residents either consume or sell to support their children's education in the mainland. Therefore, high resilience of the community and heavy reliance on the coast for food and livelihood suggest that the presence of geohazards cannot be used to justify the displacement of the coastal island communities which would impact thousands of Filipino families.

Potential impact of the Bulacan Aerotropolis project

Construction of the Bulacan Aerotropolis will bring both permanent and temporary changes to the immediate vicinity and nearby areas. Thus, it is important to consider potential effects in all stages of development (i.e., construction and operational stage) to the social, physical, and environmental resources of the area (Entec, 2005).

One of the immediate and obvious effects would be the alteration of the physical environment. Loss and reclamation of land, changes in river and drainage pathways, and removal of natural flora and fauna, consequently, influence the sediment and water transport pathways (Douglas and Lawson, 2003; Entec, 2005). If the risk is unmitigated, these could lead to flooding and siltation in nearby areas.

Pollution is another problem that should be taken into consideration. Air and noise pollution are unavoidable during construction and operation. Air pollution may come from the emissions of aircraft, ground service vehicles, and transportation in and out of the airport (Douglas and Lawson, 2003). Noise pollution, on the other hand, may be caused by construction, airborne activities (e.g., sonic booms, landing and take-off noise, engine testing), ground operations, and road traffic noise (Douglas and Lawson, 2003). Water and soil pollution near airports is also possible if waste is not properly managed. Inadequate treatment of waste and leakage from waste storage may infiltrate the soil and also flow into bodies of water, thus polluting them (Douglas and Lawson, 2003). Excessive pumping of groundwater may also cause saltwater contamination in aquifers, and subsidence from compaction.

Rapid subsidence rates have been a problem in Manila Bay at least since the 1980s, especially along the areas of KAMANAVA (Rodolfo et al., 2003, Siringan and Rodolfo, 2003, Soria et al., 2005). Construction of large infrastructures such as airports will further aggravate the problem due to increased loading. This is the case for airports on deltas (e.g., Vancouver International Airport; Nice Côte d'Azur International Airport) or reclaimed islands (Kansai International Airport; Chep Lap Kok International Airport) (Cavalié et al., 2015, Mesri and Funk, 2015, Mazotti et al., 2009, Douglas and Lawson, 2003).

Typically, airports initiate programs to control bird populations, due to the potential hazard of a bird strike on aircraft. For example, Eastern Air Lines Flight 735 crashed shortly after takeoff from Logan International Airport, Boston in 1960, killing 62 of 72 passengers (Civil Aeronautics Board, 1962). US Airway Flight 1549, after takeoff from LaGuardia Airport, New York City lost engine power due to ingestion of geese (National Transportation Safety Board, 2010). Fortunately, the US Airways aircraft made a successful emergency water landing on the Hudson River, with all 155 onboard alive.

There is a significant impact on the social and physical environment of people living near the airport when all these changes are taken into consideration. The construction of the aerotropolis greatly affects their livelihood which is highly dependent on the rich aquatic resources of Manila Bay. It could also aggravate existing hazards or bring in new hazards to their communities

With large development projects such as the Bulacan Aerotropolis, the perspective of the people that would be impacted are rarely meaningfully considered nor consulted (Salamat, 2019). Aside from the geological hazards, the people's socio-economic realities (community and livelihood) exposes them to risk. These increase their vulnerability and their ability to "respond, to cope with, or recover from the damaging effects of disaster events" (Reijmans, 2001). As such, when disaster occurs, these conditions may increase the severity of the disaster, and may further impoverish the impacted communities (Anderson, 1989).

Articulation of Results to the Brgy. Taliptip Communities

A workshop on the results of the study was held on June 1, 2019 in a chapel at Sitio Bunutan, Brgy. Taliptip, Bulakan, Bulacan. A total of 30 participants attended from three of the seven surveyed sitios. The event was facilitated by the project implementers in partnership with AKAP KA Manila Bay and AGHAM. The program started at 10:00 am with the opening remarks given by a member of AKAP KA (Fig. 24). Each of the participants were introduced, most of which were from sitios Bunutan and Dapdap. There were no participants from sitios Camansi, Capiz, Capol, and Pariahan.


National Institute of Geological Sciences
University of the Philippines Diliman
Katuwang ang AGHAM at AKAP KA

AGHAM

AKAP KA MANILA BAY

Pagpapaliwanag patungkol sa kapaligiran at mga sakuna kaugnay ng nagbabadyang reklamasyon sa hilagang baybayin ng Look ng Maynila

Brgy. Taliptip, Bulakan, Bulacan
Hunyo 1-2, 2019

Sa pakikipagtulungan ng mga Sitio:
Capol, Bunutan, Dapdap, Kinse, Pariahan, Camansi
Sa suporta ng Opisina ng Bise Tsanselor para sa Saliksik at Pagpapaunlad
Unibersidad ng Pilipinas Diliman

KONKLUSYON

- Karamihan ng mga residente ay di sumasang-ayon sa aerotropolis project kahit magkakaiba ang kanil-ang edad, hanapbuhay, kakayanang pinansyal, at panahon ng paninirahan.
- Hindi alintana ng mga residente ang mga panganib sa kadahilanang wala pang naitalang sakuna na naganap.
- Ang mga panganib ay hindi maaring gamitin para ipilit ang pagpapaalis ng mga komunidad.

EVACUATE, NOT RELOCATE!
LIKAS HINDI LAYAS!

PROGRAMA

1000 - 1010 H	**Pagpapakilala** *AKAP PA*
1010 - 1020 H	**Pagpapakilala ng Proyekto** *Dr. Sandra Catane*
1020 - 1040 H	**Palaro**
1040 - 1055 H	**Anyong lupa at tubig (Geomorphology)** *John Romel Flora*
1055 - 1125 H	**Panganib (Hazards)** *Jethro Capino*
1125 - 1245 H	**TANGHALIAN**
1245 - 1300 H	**Resulta ng Pananaliksik** 1. Profile ng mga nakapanayam 2. Mga panganib sa Taliptip *Dr. Sandra Catane*
1300 - 1315 H	3. Katatagan (Resilience) at Pag-angkop (Adaptation) *Chatty Go at Warner Carag*
1315 - 1330 H	4. Pagtanggap sa mga proyekto sa Taliptip 5. Pag-alalay ng pamahalaan (hinggil sa reklamasyon at sa mga sakuna) *John Romel Flora*
1330 - 1400 H	**Mga katanungan mula sa mga kalahok (Q and A)**
1400 - 1415 H	**Palaro**
1415 - 1435 H	**Pagtatasa (Evaluation)**
1435 - 1505 H	**Presentasyon ng bawat grupo**
1505 - 1520 H	**Pagsasara** *AKAP KA*

Figure 24. The program of the community workshop.

The objectives of the study were presented, followed by a short ice breaker to engage the audience to actively participate in the workshop. The discussion proper started with a lecture on the geomorphology and the geologic history of the Manila Bay area, followed by a discussion on the various geohazards (earthquakes, flooding, and storm surges) that the residents of the area often encounter. The causes and mechanism of each geohazard were described in detail. The participants were asked to share their personal experiences with geohazards. Additional materials used for the community workshop can be found in Appendix 4.

Results of the survey were presented, which included the profile of the respondents, geohazards in Taliptip, resilience and adaptation of the community, responses of the participants to the upcoming project in Taliptip, and relocation/assistance planned for the community by the government. Questions were entertained during the open forum after the discussions. A transcript of the open forum is provided in Table 3.

Table 3. Questions raised by the participants during the open forum, and corresponding answers. Bracketed sentences are meant to explain the context of the responses. The original Filipino transcript is in Appendix 5.

Questions	Response
1. Why do some people agree with the relocation?	Participant: They feel like they cannot do anything [about the relocation]. If they were to be relocated, they want to be near the shore so that they can keep their livelihood.
2. Can you help us (residents) inform them (San Miguel) of our rights?	Facilitator: We will prepare a report and provide you with a copy. [This report can be used to draft a counter-EIA for the aerotropolis proponents government and to realize its impact on the residents.]
3. Why do residents of Sitio Pariahan agree with the relocation?	Participant: The barangay captain promised them that they will not be relocated to a far place. This is what they are holding on to. Participant: They are not speaking out because their area is already underwater. [Relocation is an acceptable option for them.]

	Facilitator: They see the urgency and the dangers of the rising waters. Their area is becoming more dangerous to live in.

The participants also expressed their views and opinions regarding the construction of the aerotropolis in their community. Most of those who are against the aerotropolis worry that the relocation site may not allow them to have a source of income. They resist relocation because their main livelihood is in Taliptip. Some expressed that they will not directly benefit from the aerotropolis project as they lack skills needed in the construction industry, i.e., airport construction.

According to some of the participants, some residents who agree to leave or have already left expressed hopelessness and resignation about the situation. Their houses were already damaged or uninhabitable. Some said that they will only agree to leave on the condition that the government will provide compensation and that the relocation site is near the shore, so that they can still resume their lives, akin to what they are accustomed to in Brgy. Taliptip.

The open forum was followed by another icebreaker. It was succeeded by an evaluation activity where participants were divided into groups and were tasked to answer four questions as follows:

1. What happens during an earthquake, storm surge, and/or flooding? Give concrete examples.

   The participants narrated their experiences on earthquake-induced ground shaking, flooding, and swelling waves. They fear for their lives in times of calamities and they also recognized the need to evacuate. Some participants emphasized that despite the occurrence of storm surges and flooding, there were no casualties or serious injuries so far.

2. How can you prepare for hazards brought by earthquakes, storm surges, and/or flooding?

Participants said that they reinforce their houses by bracing, anchoring, and securing their roofs. They usually prepare their belongings beforehand and place them on elevated sections of their houses in case flooding occurs. They also store food in advance, especially for their children.

3. What will be the effect of the aerotropolis project to your community? Give concrete examples

   Most of the participants think that they will lose their livelihood and become poorer. They also mentioned that their families will be separated from each other since they might be displaced in different relocation sites. One participant also mentioned that if their place will be reclaimed, there is an increase in the severity of flooding.

4. Given the option, are you going to move or stay in Brgy. Taliptip? Why?

   All participants chose to stay in their respective sitios, given the choice. Their main reasons is that their source of livelihood is in Brgy. Taliptip. They emphasized that they were born and raised in Taliptip, thus they are accustomed to life there. They also feel safe and enjoy a peaceful life in their communities.

The original questionnaire and the responses were written in Filipino, and can be found in Appendix 5.

The answers and explanations of each group were summarized to the assembly. A raffle was held and tokens were handed out. One of the leaders of a local organization thanked the project implementers for holding a workshop, which gave them a platform to discuss their situation and express their sentiments amidst the Aerotropolis Project. The workshop concluded with a photo shoot with the implementers and participants (Fig. 25). More photographs of the community workshop can be found in Appendix 6.

Figure 25. A group photograph of the implementers, partners, and the participants at the end of the community workshop.

Project workshop

A workshop was held at BARCIE Hotel, La Consolacion University, Malolos City, Bulacan by the project implementers to put together field and secondary data, and discuss the results. A draft of the terminal report was prepared after thorough analysis and long discussions.

Conclusions

Most sitios of Brgy. Taliptip are built upon shallow tidal flats of the tidal-dominated Pampanga delta system. Four major geohazards were identified: earthquake, tidal and fluvial flooding, storm surge, and subsidence. These geohazards are commonly present and consistent with the geology, geomorphology, and hydrometeorological setting of the area. The first three hazards corroborated with anecdotes of residents while subsidence, though unreported, remains a threat based on earlier studies.

The construction of the Bulacan Aerotropolis causes temporary and permanent changes which impact the social, physical, and environmental resources of the communities living nearby. It is important that these effects are studied properly, incorporated in the planning and design of the project, and strictly implemented during operation.

Repeated engagements with the coastal communities through formal and informal discussions, workshops, and interviews revealed that residents have been living in northern Manila Bay for more than six decades. In the past, the communities consisted of the families and descendants of salt farm and aquaculture workers, artisanal fisherfolk, and immigrants from neighboring towns. Three generations later, most of the residents of the coastal communities are still fisherfolk and depend primarily on the Bay for their livelihood, supplemented by other sources of income.

The people of the coastal communities in Brgy. Taliptip witnessed and survived the changes in the environment through time. These environmental changes were tightly connected to their livelihood and culture. When the salt ponds and the bigger fish pens were inundated due to several storm events and related hazards, residents shifted to small-scale aquaculture, artisanal fishing, and shellfish gathering. This shift in the livelihood in relation to the changing environment was gradual and the residents had the related skills to continue their livelihood in a slightly different environment. With the imminent reclamation of the 2,500 ha to give way to the construction of the Bulacan Aerotropolis, displacement of the residents will cause a great shift in their environment - and as such, in the needed skills from which the people of Taliptip would earn their living. Thus, there is a general fear among the residents that upon the construction of the aerotropolis, many of them will be further impoverished because of their lack of marketable skills and low levels of education in an urban setting. Many residents express grave concern that even if the project proponents would offer them airport jobs, they would not directly benefit since they lack the appropriate skills.

More importantly, because much of their daily activities and most of their lives have been connected to the coastal environment, residents feel that a great part of their identity may indeed be lost to such development projects.

Recommendations

The situation of the people of Taliptip, Bulakan, Bulacan may be a case of development aggression, which is defined by Nadeau (2002) as the process of displacing people from their land and homes to make way for development schemes imposed from above without consent or public debate. People become victims and not beneficiaries of the development, and they are set aside in development planning instead of being partners with roles in decision-making (Reijmans, 2001).

Although San Miguel Corporation offers relocation for some of the affected communities (Lucas, 2019) the lack of or non-disclosure of any concrete plans prevents authorities and experts from assessing the hazard risks in the purported relocation sites. This may inadvertently expose the residents to more hazardous environments wherein the residents may not have the resilience to cope with. Also, relocation may cut off residents from accessing their livelihood and destroy their community structures, thus gravely weakening their abilities to recover once a hazardous event occurs. It is recommended that San Miguel Corporation involve the residents of Taliptip, Bulacan and the public transparently and democratically in every step of the project - before, during, and after project proposal and implementation.

Deltas, wetlands, and lakes are not ideal for airport construction because they are generally underlain by alternating layers of sand, silt, and clay, which are geotechnically problematic, i.e., low shear strength, compressible, expansive, and liquefiable. Although technological and engineering remediation may provide some solutions, developed countries like Japan, USA, UK, Norway, France, Italy, and Russia continue to face challenges in design and construction.

Published geological hazard literature categorizes the northern and eastern shores of Manila Bay as highly susceptible to flooding: 1-4 m high storm surges, tidal, and fluvial flooding; land subsidence due to over-extraction of groundwater; and high-magnitude earthquakes, which is overdue in the case of the MVFS.

The large-scale development of northern Manila Bay into an aerotropolis and business centers, which would attract immigration, may increase the hazard vulnerability of future workers, residents, and establishments. It is highly recommended that the project proponents consider an alternative site location and reduce the scale of the Bulacan aerotropolis project.

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