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REPORT

North Manila Bay Flood Protection Strategy

Main report

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Abbreviations

Abbreviation	Explanation
ABB-BP	Alyansa ng mga Baybaying Bayan sa Bulacan at Pampanga
ADB	Asian Development Bank
AO	Administrative Order
BACSEZFA	Bulacan Airport City Special Economic Zone and Freeport Zone
BMB	DENR - Biodiversity Management Bureau
BFAR	Bureau of Fisheries and Aquatic Resources
CAPEX	Capital Expenditures
CLD	Coastal Line of Defence
CLUP	Comprehensive Land Use Plan
DBM	Department of Budget and Management
DENR	Department of the Environment and Natural Resources
DILG	Department of Interior and Local Government
DISB	Disclosed Institutional Situation and Bias
DOTr	Department of Transportation
DPWH	Department of Highway and Public Works
DRR	Dutch Risk Reduction team
ECC	Environment Compliance Certificate
ENIPAS	Expanded National Integrated Protected Areas System
EMB	DENR - Environmental Management Bureau
EO	Executive Order
FGD	Focus Group Discussion
FLA	Fisheries Lease Agreement
GCF	Green Climate Fund
ICM	Integrated Coastal Management
ICZM	Integrated Coastal Zone Management
IFI	International Financial Institution
IPCC	Intergovernmental Panel on Climate Change
IRA	Internal Revenue Allotment
JICA	Japan International Cooperation Agency
KRA	Key Result Areas
LGU	Local Government Unit
LIDAR	Light Detection and Ranging
MBSDMP	Manila Bay Sustainable Development Masterplan
MBCO	DENR - Manila Bay Coordinating Office
MBTF	Manila Bay Task Force
MGB	Mines and Geosciences Bureau
NbS	Nature-based Solutions
NDRRMC	National Disaster Risk Reduction and Management Council
NEA	Netherlands Enterprise Agency
NEDA	National Economic and Development Authority
NGA	National Government Agencies
NGO	Non-Government Organization
NMIA	New Manila International Airport
OCHA	United Nations Office for the Coordination of Humanitarian Affairs

Abbreviation	Explanation
ODA	Overseas Development Assistance
OPEX	Operating expense
OPMBCS	Operational Plan for the Manila Bay Coastal Strategy
PAGASA	Philippine Atmospheric, Geophysical, and Astronomical Services Administration
PAPs	Programs, Activities, and Projects
PDP	Philippine Development Plan
PENRO	Provincial Environment and Natural Resources Office
PPA	Philippine Ports Authority
PRA	Philippine Reclamation Authority
PSA	Philippine Statistics Authority
PSF	People's Survival Fund
RA	Republic Act
RDC	Regional Development Council (NEDA)
RHDHV	Royal HaskoningDHV
SMC	San Miguel Corporation
SSP	Shared Socioeconomic Pathways
WB	World Bank

Executive Summary

The North Manila Bay Flood Protection Strategy aims to increase the resilience of people and businesses against flooding in the North Manila Bay area using Nature-based Solutions. The strategy shows that Nature-based Solutions are vital in offering protection from climate change impacts and other flood-related hazards. At the same time, they can provide a transition towards alternate/adaptable livelihoods and habitat restoration. This way, the North Manila Bay Flood Protection Strategy contributes to increasing and restoring the biodiversity in the North Manila Bay area.

This strategy determines ten root causes for the flooding problems in the North Manila Bay area. Important among these are the decline of natural habitat, climate change-induced sea-level rise and land subsidence. By conducting various stakeholder sessions and interviews, these root causes have been confirmed, and applicable Nature-based Solutions have been shaped accordingly. This resulted in a set of twenty possible Nature-based Solutions and “soft-measures” that will positively impact the flood susceptibility of the region if implemented. This strategy acknowledges that there are many parallel and interfacing developments in the area and that coordination and alignment between these developments are fundamental for their individual success.

Combining a wide array of data such as geospatial information, stakeholder interviews and domain knowledge of our experts, the North Manila Bay Flood Protection Strategy identifies proposed priority locations for the implementation of Nature-based Solutions. The priority locations are divided in the inland main population centres (such as Hagonoy), critical infrastructure and smaller population centres closer to Manila Bay. The main population centres will need to be provided sustainable protection due to the predicted population expansion of Metro Manila towards these areas. For the smaller population centres near Manila Bay the strategy provides small scale Nature-based Solutions that help the inhabitants in their resilience against flooding in the short-term. In line with the Manila Bay Sustainable Development Masterplan the aim is to motivate inhabitants to move/relocate more inland. Due to sea-level rise and land subsidence, the area is not suited and sustainable for further urban development.

Given the current institutional setup, it can be concluded that due to resourcing and financial limitations, the Local Government Units cannot implement the national and regional regulations and cannot find the right “route” to source funding. Based on the recommended solutions and technical implementation, the strategy provides an institutional setup for the short-term, which is focused on initializing possible projects through the LGU with support from 3rd parties such as DILG, regional government agencies and the ABB-BP. For the long-term, connection with the Manila Bay Sustainable Development Masterplan is envisioned

Especially in the short-term it is important to implement pilot projects for Nature-based Solutions because they will provide a good example project, which can act as a basis for further implementation of the wider strategy. Besides the strategy for the wider North Manila Bay area, this strategy also provides two concepts for pilot implementations; restoring a part of the sediment accretion in the Pampanga river mouth and Nature-based “green” embankments.

The North Manila Bay Flood Protection Strategy shows that the time to act on flood-related problems for the area is now. If no substantial change is made in the manner in which flood protection is provided, inhabitants of the area will be increasingly exposed to worse flooding, and natural habitats will further decline. Nature-based Solutions bring sustainable solutions for flood protection and at the same time offer opportunities for transforming and adapting livelihood. And moreover, they will restore part of the natural habitat, which used to be one of the Philippines' most important bio diversity areas.

The stategy can be viewed online via https://northmanilabayfps.ireport.royalhaskoningdhv.com/

Summary

In the next 40 years, it is expected that the urban area in the catchment of Manila Bay will roughly have doubled, with an increase of population from 33 million people in 2015 to about 51 million people by 2050. This requires the greatest attention of the Government of the Philippines in order to adequately regulate the spatial and master plans. In response to the need for a comprehensive plan for Manila Bay, the National Economic and Development Authority (NEDA) initiated in 2018 the formulation of the Manila Bay Sustainable Development Masterplan(MBSDM). The Government of the Philippines (through NEDA) and the Government of the Kingdom of Netherlands (through the Ministry of Foreign Affairs) completed the Manila Bay Sustainable Development Masterplan by the end of 2021.

One of the priority measures of the Manila Bay Sustainable Development Masterplan is to drastically reduce people, properties, and livelihood exposure to flooding, especially informal settler families in hazard-prone areas, by establishing a coastal line of defense (CLD), relocating residents in extreme-subsiding barangays (i.e., seaward of the CLD) and implementing nature-based coastal protection programmes.

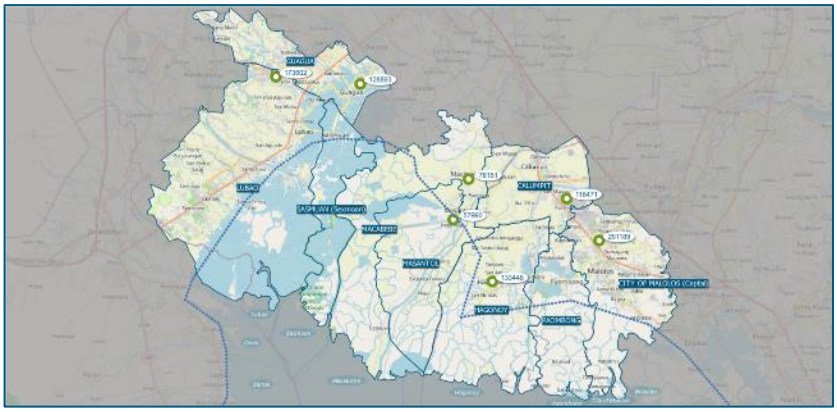
The coastal line of defense is proposed in the Manila Bay Sustainable Development Masterplan to provide flood protection for the areas north of it. The alignment of the coastal line of defense more or less follows the historical coastline of the north manila bay area.

Based on the Manila Bay Sustainable Development Masterplan the Netherlands Enterprise Agency identified increased exposure to flooding as one of the major issues and threats to the development of Manila Bay in the coming 50 years, particularly in the northern coastal area. Therefore, the Netherlands Enterprise Agency requested for proposals to develop the North Manila Bay Flood Protection Strategy in August 2021; Royal HaskoningDHV was awarded the strategy and have completed it by February of 2022

The goal of the North Manila Bay Flood Protection Strategy is:

"To develop a Flood Protection Strategy which identifies sustainable, nature-based flood protection measures for the Northern Manila Bay coastal area, and to recommend pilot locations for implementation of these measures."

With this goal, the North Manila Bay Flood Protection Strategy gives substance to one of the priority measures of the Manila Bay Sustainable Development Masterplan: to "Reduce Exposure in Flooding", action: "REF003 | Design and Implement Nature-Based Flood Protection Solutions" [1]. The designed and implemented project can be an example and catalyst for further implementation of Nature-based Solutions.



North Manila Bay Flood Protection Scope area

The physical scope of the strategy is focussed on the area surrounding and south of the coastal line of defence in the Provinces of Bulacan and Pampanga. The strategy also provides Nature-based

Solutions(NbS) north of the coastline of defence to reduce fluvial flooding. It identifies Nature-based Solutions that can be implemented along the coastal line of defence, and it provides a wide array of Nature-based Solutions to protect the people who live outside of the coastline of defence, in the North Manila Bay area.

For the past decade, up to the present day, North Manila Bay Delta is and has been part of various research studies. Amongst which are the Manila Bay Sustainable Development Masterplan and the Landscape Proposition for North Manila Bay by Wetlands International. The area also harbours several major construction projects such as the New Manila International airport, river training schemes and dredging projects. The North Manila Bay Flood Protection Strategy considers the various components, interests, ideas, and opportunities this collection of interfaces presents. This strategy provides an overview and gives a snapshot of the vast amount of information and data currently available on the subjects discussed. However, overlap and conflicting interests of these interfaces remain a point of attention in the years to come.

This North Manila Bay Flood Protection Strategy's foundation is a root cause analysis into the flooding problems. The following root causes are identified:

- **Delta characteristics**
  The North Manila Bay area is a river delta. River deltas are naturally low-lying areas formed by a balance between the accretion and erosion of sediment. This natural character of the area increases its proneness to flooding.
- **Population expansion**
  The historic coastline of the North Manila Bay Delta lies north of several of the current population centres. It is estimated that 300,000 people live seaward of the historic coastline. The population growth models show that the population north of Metro Manila will increase for the coming decades, especially in the Bulacan and Pampanga areas
- **The decline of natural habitat**
  The North Manila Bay Delta used to have large mangrove and tidal flat areas that would act as natural flood defence. Mangroves and tidal flats capture the sediments coming from the rivers upstream, allowing them to grow together with water level changes. This natural habitat has been removed due to human activity. With the natural habitat gone, the ability of the North Manila Bay natural defence system to reduce disasters with rising sea level and subsiding ground level has also been substantially reduced.
- **Storm surges**
  Storm surge heights are significant. Studies on hindcast data and data collected from the site visits show that water level elevations (storm surges) have reached up to 2 meters above Mean Sea Level (MSL) during severe typhoons. From a statistic perspective, surges up to 3 to 4 meters are possible during more rare events.
- **Erosion and sediment shortage**
  Due to the loss of mangrove areas and river canalization, the North Manila Bay Delta holds much fewer natural sediments than 70 years ago. The sediments acted as a natural flood barrier and ecological habitat.
- **Climate change**
  The most conservative emission scenarios show 0.9 m of plain sea level rise can be expected within the next 50 years. If plans for reducing carbon emissions worldwide are adopted to have the most optimistic effect, 0.6 m of plain sea level rise can still be expected.
- **Fluvial flooding**
  The progressing cultivation of the mangrove areas and conversion of tidal flats adjacent to rivers, the canalization of the rivers, and restrictions of the natural river flow in the form of narrow dikes and fishpond expansion have reduced the discharge and storage capacity of the river systems.

- **Local rainfall**
  Road and riverbank elevation (to compensate for subsidence) without proper adjustments of the local drainage systems has led to water clogging in many places within the study area.
- **Land subsidence**
  Land subsidence resulting from excessive extraction of groundwater has caused a significant lowering of land levels in wide parts of the North Manila Bay Delta, up to an average of 0.05 m per year. At this moment, land subsidence in many areas is contributing to flooding much more than the sea level rise
- **Sediment extraction**
  There are several existing mining concessions close to the North Manila Bay Delta coastline and within the rivers. These concessions entail the extraction of marine and river sand, aggregates and other minerals. When these areas are mined, the seabed will transform (will become deeper), leading to a disturbance of the current morphological layout of the North Manila Bay Delta, with a risk of increasing flood exposure.
- **Institutional and organisational setup**
  Stakeholder consultations showed that the Local Government Units (LGU) are aware of the problems and deal with the impacts of flooding on a day-to-day basis. Existing legislation within the Philippines offers tracks for support and funding of solutions for these vulnerable LGUs but in practice, the LGUs do not have the resources to organize and plan for tapping into national government resources. It has been observed that in most flood protection works, the focus is on the capital expenditure costs (CAPEX) and not so much on the life cycle costs of a project, which is one of the key benefits/drivers for Nature-based Solutions.

The North Manila Bay Flood Protection Strategy sees the decline of natural habitat, erosion and sediment shortage, sediment extraction and the institutional setup as endogen which proactive measures can change. The other root causes are exogen and require reactive measures as a solution.

Given these root causes, Nature-based Solutions seem to be a perfect fit to resolve some of the causes for the flooding problems. Nature-based Solutions address infrastructural needs, offer protection from climate impacts and act as hazard mitigation tools while they contribute to restoring eco-system benefits and biodiversity.

"Nature-based Solutions are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."

System understanding is the key for successful implementation. In-depth knowledge about the physical system as well as the socio-economic system and governance context is essential to identify potential win-win situations. The North Manila Bay Flood Protection Strategy gives substance to these factors. This strategy gives an overview of 20 potential Nature-based Solutions measures and related "soft" project implementations. These 20 measures are assessed based on various criteria that allow for matching them to area suitability and proposed priority locations most exposed to these flood-related aspects.

Stakeholders

The stakeholder engagement of this strategy aims to engage the stakeholders in a meaningful way, considering their aspirations, sentiments, and recommendations at different project stages. It is based on the belief that people and entities affected by the North Manila Bay Flood Protection Strategy have a right to be involved in the decision-making process. By recognizing, communicating, and reflecting the interests and needs of the different stakeholders, sustainable decisions may be ensured. A total of approximately 50 meetings/workshops were held to collect input and opinions spread over 20 different stakeholders. The results showed a complex situation for the North Manila Bay Delta in which large-scale economic developments and ongoing cultivation of lands pressure the restoration options and protection of natural habitats and ecosystems. However, there also is widespread understanding and willingness to act now on flood protection and habitat restoration to prevent more disasters in the future.

The North Manila Bay Flood Protection Strategy team has conducted 8 (day) site visits in which local officials were visited, and workshops were held as part of the stakeholder involvement efforts. Several barangays and rural areas in the North Manila Bay Delta were visited. During the site visits, approximately 80 household surveys were held to acquire data on how local residents perceive the impact of flooding and the main causes and solutions for it. Results of these household surveys are available via the online iReport website of the strategy. As part of the site visits, aerial footages (drone imagery) were collected, which are also available via the online iReport.

Analysing and identifying the right institutional setting is pivotal for both the wider strategy's success and proposed pilot projects. There are current institutional and regulatory frameworks in place which could provide a foundation for implementation, amongst which are the Integrated Coastal Management (ICM) policies, the Manila Bay clean-up (AO-16) and assistance for developing LGU's. Through various meetings and workshops, an approach was developed for both the strategy and the proposed pilot location that uses the existing institutional and regulatory frameworks while also adding guidance on implementation improvements. For the pilot projects especially, that will mean that the 2022 elections need to be awaited before any further action can be undertaken. After the elections, either the ABB-BP (organisation of unified LGUs in North Manila Bay) or a supportive LGU will need to request external funding to acquire resourcing support. Once the resources are available, the ABB-BP or LGU can start developing their Comprehensive Land Use Plans to include this strategy and in parallel request for funding of the pilot projects under the ICM framework. Besides this direct setup and funding approach, the North Manila Bay Flood Protection Strategy offers other setups or funding approaches that might be needed for the ABB-BP/LGU in developing the proposed pilot projects.

The geographical scope of the North Manila Bay Flood Protection Strategy covers the provinces of Bulacan and Pampanga; it is assumed that the strategy will need to be implemented in so-called "priority areas". This strategy identifies the following priority areas:

1. Population centres and areas south of (towards Manila Bay) the Coastal Line of Defence.

For the smaller population centres near Manila Bay, the strategy provides small scale Nature-based Solutions that help the inhabitants resilience against flooding in the short-term. But in line with the Manila

Bay Sustainable Development Masterplan the aim is to motivate inhabitants to move/relocate more inland, as due to sea-level rise and land subsidence, the area is not suited and sustainable for further urban development. New infrastructure developments will need to be discouraged while nature-based flood protection will be provided following the principles for the restoration of the coastal intertidal system. Nature-based Solutions will be focussed on measures that have a direct positive effect on the safety, livelihoods and sustainability of the living environment (ecosystems, natural resources and biodiversity) as these are interconnected.

2. Population centres along (north of) the Coastal Line of Defence

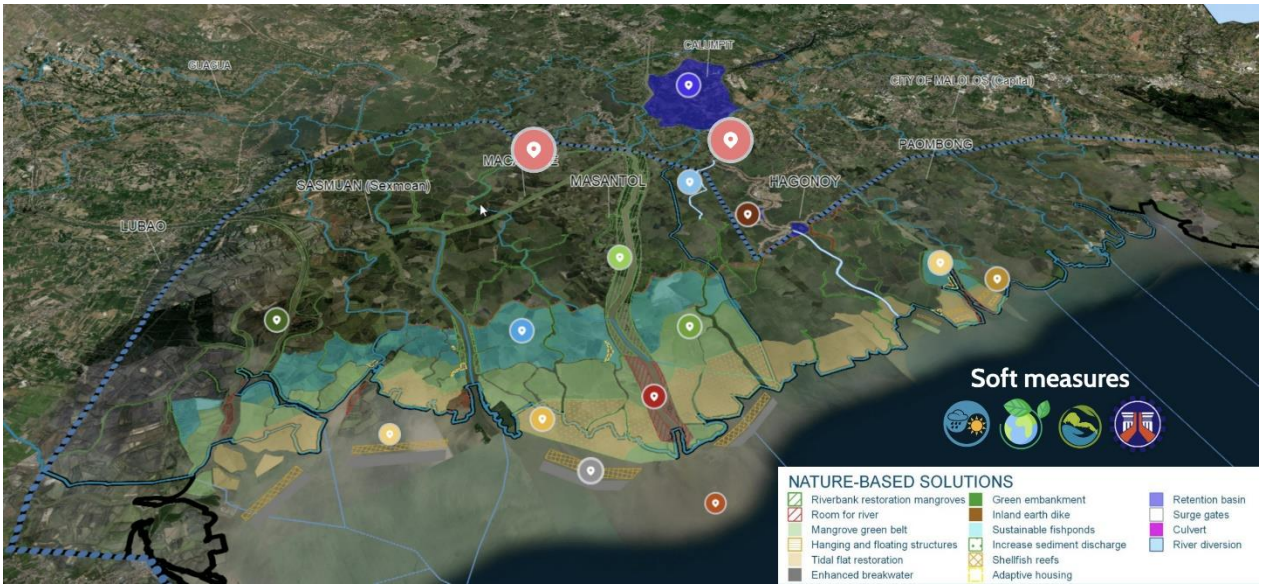
Apart from population centres, livelihoods and infrastructures are also vital for the people who live outside(north) of the CLD. The Manila Bay Sustainable Development Masterplan envisions that future development and population growth will take place north of the Coast Line of Defence and attention being paid to people that have chosen to relocate from the areas south of the CLD.

3. Infrastructure and livelihood

Nature-based Solutions on each side of the CLD are focussed on contributions towards transforming relevant livelihoods towards more sustainable and inclusive (future proof) alternatives linked to reduced flood risk along coast and rivers, and around priority population centres.

This strategy maps out these priority areas and assesses them on their exposure to the various flood related criteria. Combining this with the assessment of the 20 potential Nature-based Solutions will provide a canvas/matrix that can be used to prioritize certain projects and locations.

Based on this strategy, several maps have been developed, of which the Nature-based Solutions overview map shows what the full implementation of the strategy would look like. The map is the result of the work done in this strategy inspired by the Ecoshape/Wetlands International's proportion to DENR for the same areas and tries to balance the plans and interests of the Manila Bay Sustainable Development Masterplan, the landscape proposition by Ecoshape/Wetlands International and opinions and ideas collected during the stakeholder meetings.



Nature-based Solutions overview

It has been identified by the Netherlands Enterprise Agency that pilots projects are needed to promote and show the feasibility of Nature-based Solutions. The North Manila Bay Flood Protection Strategy identifies pilot locations as an opportunity to serve as a catalyst for implementing the strategy and Nature-based Solutions in the Philippines as a whole. Two pilot locations have been identified:

1. **Green embankments in Masantol and Macabebe**
   The current practice of constructing embankments and fishpond dikes involves lining relatively steep slopes with concrete. Due to settlement processes and concrete quality issues, these concrete "revetments" disintegrate rapidly, causing high maintenance costs, and pose a flood protection issue as the dikes could fail. By transforming these embankments into 'green embankments', the life cycle costs of these embankments will be reduced and, in the meantime, also provide habitat restoration.
2. **Pampanga river outfall widening**
   The Pampanga River outfall is a location where various issues related to flood protection, natural habitat restoration and protection of internationally critical habitats for thousands of migratory waterbirds come together. The river has been diked far further than its original outflow. The mudflats and mangrove/coastal forest are transformed into fishponds, and the riverbed and foreshore seabed are being used as sediment mining areas. The pilot aligns with the plans of the Building with Nature Asia Landscape proposition as well as DENR-BMB's ongoing effort to declare the area legally as a Critical Habitat which seeks to restore and protect natural habitats along the North Manila Bay coastline.

Together with the institutional setting, the North Manila Bay Flood Protection Strategy provides the basis to implement these pilots. Either ABB-BP or an LGU may need to use the strategy as a basis to in the short-term to issue a number of legal ordinances and in the longer-term, update the CLUPs and arrange for funding (internally or externally). The provincial, regional, and national government agencies will need to support the LGUs as they should via the existing legal frameworks.

The North Manila Bay Flood Protection Strategy team concludes that the strategy provides the tools needed to develop the North Manila Bay area sustainable towards the future, respecting the various interests of the stakeholders. It may also be a useful tool in coming up with Biodiversity Off-set Plan for the same area as required by the DENR as compliance to develop the new Manila International Airport in Bulacan. It also provides guidance for future strategy implementation within the Philippines for Nature-based Solutions.

1 Introduction

The urban area in the catchment of Manila Bayis expected to double in terms of population by the Year 2050. Due to the growing challenges in Manila Bay, such as increasing population, climate change and large numbers of unsolicited investment proposals, the National Economic and Development Authority (NEDA) initiated the Manila Bay Sustainable Development Masterplan (MBSDMP) [1], in collaboration with the Government of Netherlands.

On the urgency to address the growing Manila Bay challenges, on February 2019, the President of the Philippines, His Excellency Rodrigo Duterte issued Administrative Order No. 16 – expediting the rehabilitation and restoration of the coastal and marine ecosystem of the Manila Bay and creating the Manila Bay Task Force (MBTF) under the leadership of DENR Secretary Roy Cimatu. The MBTF divided the task with the creation of the Key Result Areas (KRA) with KRA 7 (under the leadership of NEDA), including the formulation of a master plan – Manila Bay Sustainable Development Masterplan (MBSDMP). The MBSDMP complements and builds on the outcomes of the short-term plan (up to 2022) of the MBTF that are intended largely for cleaning up the Manila Bay. This also gives an opportunity to ensure ownership within Philippine government agencies for the follow-up of the MBSDMP activities. Likewise, NEDA is in discussion with line-agencies and local government units regarding the follow-up.

The Manila Bay Sustainable Development Masterplan Is a comprehensive Masterplan aiming to protect and improve the Manila Bay ecosystem and the surrounding communities. The success of MBSDMP is dependent upon four pillars. One of the pillars is “Prompt implementation of its six priority measures” to bridge the gap between the current state of Manila Bay and the projected goal in 2040. One of these priority measures is to:

"Reduce the exposure of people, livelihood, and properties to flooding."

To obtain this, the Manila Bay Sustainable Development MasterplanManila Bay Sustainable Development Masterplan includes strategies not limited to establishing an institutional set-up, promoting environmentally friendly developments, opportunities to increase their livelihood, and guidance to implement priority Programs, Activities, and Projects (PAPs).

Discussions with development partners, the Philippine government and Dutch organizations indicate a willingness to take the activities forward. However, the actions proposed in the MBSDMP Action Plan and Investment Report are mostly not precise enough for implementing agencies, investors and donors to move them forward. In 2021, The Netherlands Enterprise Agency commissioned a team of experts to formulate follow-up projects considered to be a priority by both government, stakeholders and development partners. One of these priority projects is the formulation of flood protection measures for the northern coast of Manila Bay.

The Manila Bay Atlas [2] which is part of the MBSDMP shows that Metro Manila will rapidly expand northwards into the provinces of Bulacan and Pampanga in the years to come. The provinces are adjacent to Manila Bay and are part of the North Manila Bay Delta, harbouring two main river outflows; the Pampanga River and Angat River. Decades of expanding the coastline, sea-level rise, river flow narrowing, and in recent decades rapid land subsidence makes the North Manila Bay Delta area increasingly vulnerable to flooding.

Due to the frequently occurring floods and the projected population expansion towards North Manila Bay, the Netherlands Enterprise Agency and the Dutch Embassy tendered the North Manila Bay Flood

Protection Strategy. Royal HaskoningDHV was awarded the project in September 2021. The North Manila Bay Flood Protection Strategy was finalized in February 2022.

Figure 1-1: Typical coastline view North Manila Bay

As described, the flooding can be attributed to several factors, and the MBSDMP has defined that Nature-based Solutions should be part of a suitable and sustainable flood protection solution to protect the property livelihood of people living at the coast in the North Manila Bay, as well as restoring and protecting environmentally essential biodiversity areas. Moreover, when applied correctly, Nature-based Solutions provide more economic life cycle costs solution for flood protection than traditional engineering solutions.

This study is named the North Manila Bay Flood Protection Strategy, a follow-up from the MBSDMP, and is funded by the Netherlands Enterprise Agency. The North Manila Bay Flood Protection Strategy is focussed on the priority measures of the MBSDMP, in particular, the measure "Reduce Exploring in Flooding" action plan, action: "REF003 | Design and Implement Nature-Based Flood Protection Solutions" [1]. The goal of this strategy is:

"To develop a Flood Protection Strategy which identifies sustainable, nature-based flood protection measures for the Northern Manila Bay coastal area, and to recommend pilot locations for implementation of these measures."

The Team

The Netherlands Enterprise Agency is represented by:

• Matthijs Zijlmans –Program Advisor	Netherlands Enterprise Agency
• Rien van Zetten - Senior flood consultant expert	Rijkswaterstaat

The North Manila Bay Flood Protection Strategy team consist of the following senior staff:

• George Peters – Project Director	Royal HaskoningDHV
• Jan Willem Nell – Technical Director	RoyalHaskoningDHV
• Marylene Labitan Project Manager	Royal HaskoningDHV
• Jeffrey Alfred Tanael – Project Manager	Royal HaskoningDHV
• Jan-Jaap Brinkman – Senior Advisor	Deltares
• Arne Jensen – Senior Ecologist and Biodiversity expert	Nordic Agency for Ecology and Development
• Petra Dankers – Building with Nature expert	Royal HaskoningDHV

- Rose Calilung – Stakeholders consultancy expert — Independent consultant
- Atty. Rafael Chris Teston – Institutional expert — Independent consultant

2 Strategy guide

2.1 Reading guide

This flood protection strategy report is set up as follows; Appendix 2 provides a visual overview:

- Section 1: Introduction

  This section describes the goals and background of the North Manila Bay Flood Protection Strategy.

- Section 2: Strategy guide

  The setup and ethos of the North Manila Bay Flood Protection Strategy are presented in this section. A link to the digital report (iReport) is provided and opportunities and risks are discussed.

- Section 3: Root cause analysis

  This section describes the root causes of flood risks in the North Manila Bay Delta.

- Section 4: Stakeholders

  This section summarizes the stakeholder engagement strategy and gives an overview of the North Manila Bay area stakeholders.

- Section 5: Site visits

  This section summarizes the findings and data collected during the site visit phase of the project. All information is based on the eight site visits conducted between November 2021 and January 2022.

- Section 6: Institutional setting

  The Institutional Setting summarizes the current mandates of the governmental agencies and other institutions involved. It provides a proposed framework for the implementation of the flood protection strategy.

- Section 7: Funding

  This section summarizes the possible source of funding for North Manila Bay Flood Protection Strategy and pilot projects. Several alternative funding tracks are proposed.

- Section 8: Nature-based Solutions

  Nature-based Solutions are identified to reduce risks associated with flooding. This section gives an overview and assessment of possible Nature-based Solutions (NbS) that could be implemented in the North Manila Bay Delta.

- Section 9: Location assessment

  The location assessment uses several criteria to determine priority locations for flood protection measures.

- Section 10: Solutions

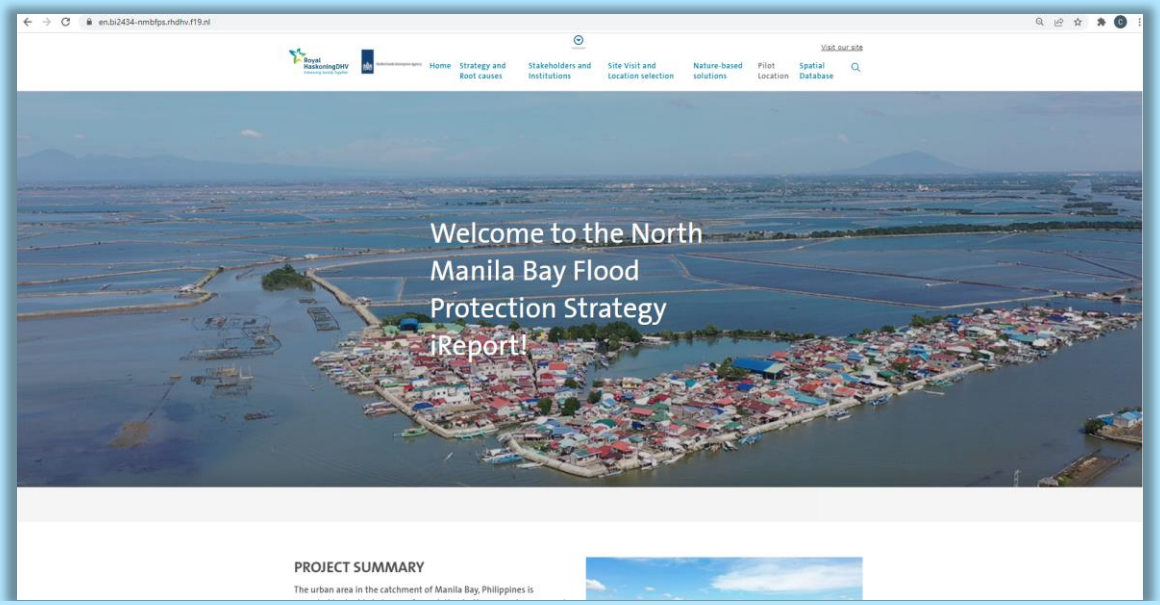
  This section presents the proposed solutions for the selected priority locations. Possible pilot projects are presented, including the layout, possible construction methodology, institutional arrangement, and conceptual cost estimates.

- Section 11: Bibliography

  Provides a full list of all references made. Minutes of meeting are only available for meeting participants. Appendix 4 has its own bibliography.

2.2 iReport

A Project website was developed to inform the stakeholders and the general public on the Project's objectives, activities, analysis, and outputs. The website is envisaged to be accessible to the general public in March 2022. https://northmanilabayfps.ireport.royalhaskoningdhv.com/



2.3 Opportunities and Risks

During the creation of the North Manila Bay Flood Protection Strategy, an opportunity and risk log was maintained. The following tables describe the primary opportunities and risks identified.

Table 2-1: Opportunities in North Manila Bay Flood Protection Strategy

Opportunity	Way forward
The landscape proposition from Wetlands International Philippines aligns with the efforts of the North Manila Bay Flood Protection Strategy in terms of implementing Nature-based Solutions.	This flood protection strategy takes as much as possible the knowledge from previous studies and tries to use that as a basis for the strategy. Both this strategy and Wetlands International are using Nature-based Solutions, therefore providing synergy between the two projects. The pilot locations following out of this strategy should be coordinated with Wetlands International Philippines.
Biodiversity offset measures for the New Manila International Airport could overlap with this strategy. The pace of the implementation could confuse stakeholders, and consultation processes might be treated differently.	During the preparation for the North Manila Bay Flood Protection Strategy, meetings with San Miguel Corporation (airport developer) and Boskalis (dredging contractor) were held in which interest for the flood protection strategy was expressed by both parties but they were not able to commit to any alignment. In December 2021 Atradius (credit export insurance Boskalis) published parts of the EIS [3] [4] [5] for the airport project. In 2022 it should be monitored how compensation/offset measures overlap/align with this strategy.

Table 2-2: Risks in North Manila Bay Flood Protection Strategy

Risk	Mitigation
The Manila Bay Sustainable Development Masterplan will not be ratified. For implementing this flood protection strategy, it is assumed the Manila Bay Sustainable Development Masterplan will be the basis.	The North Manila Bay Flood Protection Strategy provides a "small-scale" institutional setup to cover until the Strategy is in force (see Section 6). This will be a temporary solution for the pilot locations. If the Manila Bay Sustainable Development Masterplan is not ratified, the institutional setup in this strategy could be expanded to serve bigger projects.
2022 is an election year, and it will have an impact on the ability to make decisions and influence specific stakeholders.	For the proposed pilot locations, "bottom-up" institutional settings are proposed to mitigate any problems with regional/national politics. But it has to be recognized that the election also has an influence on local politics. To reduce issues with government funding during election periods, alternative funding tracks are proposed, see Section 0. After the elections (Q3 2022) this strategy should be presented again for inclusion in 2023 budgets.
The institutional complexity surrounding coastal zone management and flood protection can lead to the inability to execute new/innovative projects. Responsibilities and mandates are split over various government agencies, and practical implementation is highly dependent on motivated and funded LGU's.	The North Manila Bay Flood Protection Strategy assumes that the Manila Bay Sustainable Development Masterplan will be ratified regarding the wider flood protection strategy. For early implementation pilot projects, this strategy proposes alternative small-scale institutional setups, see Section 6.

2.4 Interfaces

This Section shows four major interfaces with the North Manila Bay Flood Protection Strategy within a 5-year horizon; this strategy will be shaped by how these interfaces develop. That is why interaction/collaboration with said interfaces is part of the success of this flood protection strategy.

2.4.1 Manila Bay Sustainable Development Master Plan

The Manila Bay Sustainable Development Masterplan (MBSDMP) [1] is an inclusive master plan for the sustainable development of Manila Bay. It is envisioned to guide decision-makers in assessing and approving programs, activities, and projects (PAPs) for implementation in Manila Bay and adjacent areas with significant influence on the bay.

The Manila Bay Sustainable Development Masterplan is consistent with the Philippine Development Plan (PDP), contributing to the achievement of the AmBisyon Natin 2040 vision and supporting internationally agreed goals such as those contained in the Sendai Framework for Disaster Risk Reduction (2015-2030) and the 2030 Agenda for Sustainable Development.

While traditional plans for coastal management and development assume public financing, the MBSDMP approach aims to include and make use of solicited private sector investments to achieve strategic management and implement development goals for the five following topics:

- Improved Water Quality
- Ecosystem protection
- Upgrading informal settlement
- Disaster Risk Reduction and Climate Change adaption
- Inclusive growth

The North Manila Bay Flood Protection Strategy is a follow-up from the MBSDMP focused on five goals and specifically giving substance to the actions regarding the Design and Implementation Nature-Based Flood Protection Solutions (REF003) [1].

The primary interfaces identified are the following topics:

- Coastal Line of Defence (CLD)
- Reduce exposure to flooding
- Restoring natural habitat and Ecosystem protection
- Institutional set-up and capacity building for MBDSMP implementation

The Strategy has a direct link with the MBSDMP and was developed with inputs from experts and organizations that were also involved in the development of the MBSDMP. For more information, visit the Manila Bay Sustainable Development Masterplan website: http://mbsdmp.com/

Important zoning considerations that will be adhered to in this strategy are given in Figure 2-1 and Figure 2-2. The figures show that the MBSDMP intends to transform the current “monoculture” of fishponds into a mixed Aquaculture, Fishery and Mangrove zoning. Integrating these three elements is a key challenge for the North Manila Bay Delta, and both the landscape propositions from Ecoshape and Wetlands Philippines (chapter 2.4.2) and this strategy aim to substantiate the proposed zoning.

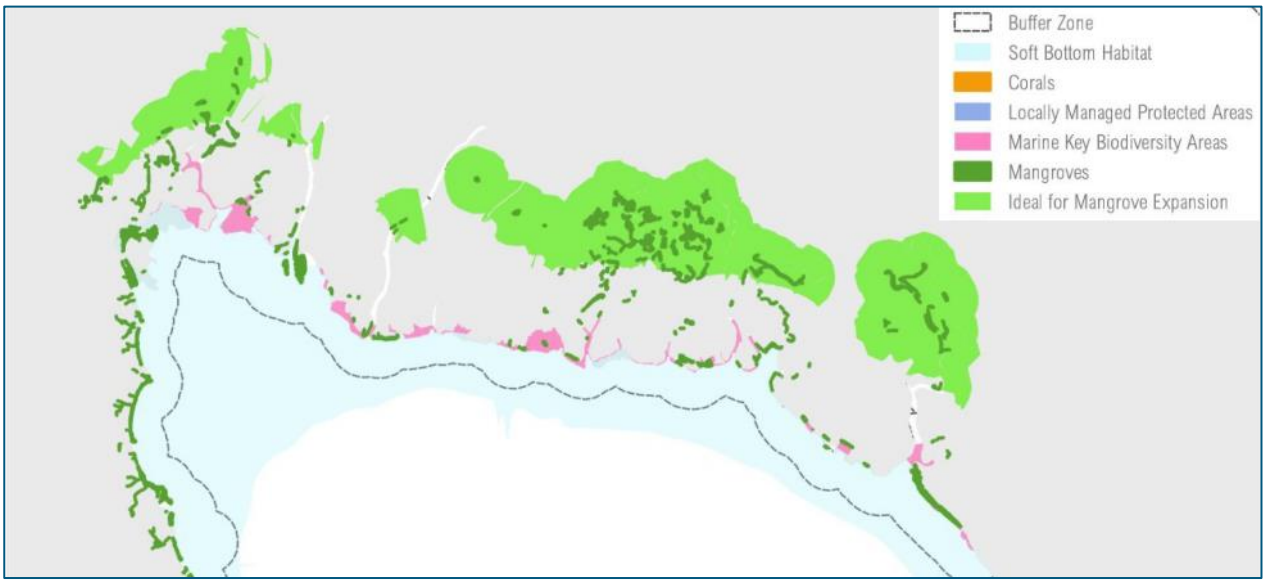


Figure 2-1: Strict protection zones [6]

Figure 2-2: Production Use Zones [6]

2.4.2 Building with Nature Asia Landscape proposition initiative

"Building with Nature Asia" (BwN Asia) is a regional initiative by Wetlands International, Deltares, and One Architecture, members of the Ecoshape Consortium [7]. BwN Asia has projects in China, India, Indonesia, Malaysia, and the Philippines. In each country, national offices of Wetlands International lead and guide the Ecoshape Consortium in developing landscape propositions to promote and implement Building with Nature solutions for climate-resilient green-grey engineering linked to ecosystem restoration, enhancing community food security and disaster risk reduction, including coastal flooding. In the Philippines, a plan has been developed for the North Coast of Manila Bay, specifically the Bulacan area. Wetlands International Philippines leads the initiative and is actively involved in several stakeholders and community engagement processes to promote BwN and the design of the landscape proposition. The proposition is endorsed by DENR.

Wetlands International Philippines has developed the landscape proposition, as shown in Figure 2-3. For the entire image, refer to Appendix 1. The proposal includes, amongst others, the restoration of natural habitats (e.g. tidal flats), creation of a mangrove belt (green), protection of critical habitat and natural resources to increase safety resilience and livelihood security of coastal inhabitants of Bulacan.

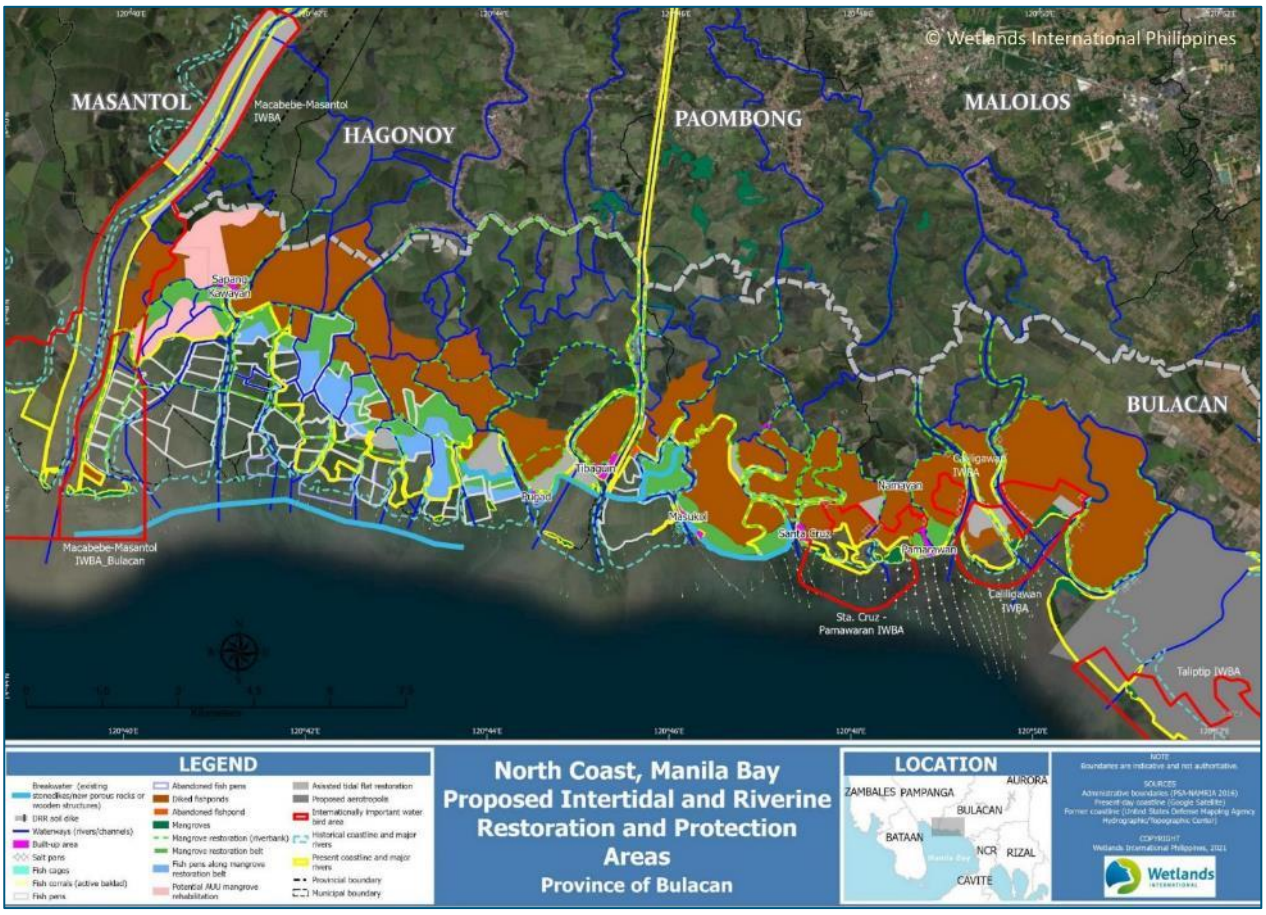


Figure 2-3: Landscape proposition of Wetlands International Philippines (Appendix 1)

During the creation of the North Manila Bay Flood Protection Strategy, Wetlands International Philippines has been involved in discussions on Nature-based Solutions and methods for North Manila Bay. Furthermore, joint webinar sessions were organized. This strategy uses the landscape proposition as the possibility for alignment of any pilot projects. It has to be noted that the objective of the landscape proposition and the flood protection strategy are somewhat different but supplementary, being habitat restoration and flood protection, respectively, both using Nature-based Solutions. It has to be noted that this strategy is not a formal product of Wetlands International Philippines.

2.4.3 New Manila International Airport

One of the ongoing projects in Manila Bay is the unsolicited proposal from San Miguel Holdings Corporation for the financing, design, construction, operation, and maintenance of the New Manila International Airport (MIA) in the Municipality of Bulakan, Bulacan. In addition, the Economic Affairs Committee of the House of Representatives recently approved the creation of the Bulacan Airport City Special Economic Zone and Freeport Zone (BACSEZFA) under House Bill (HB) No. 7575, which "shall cover the domestic and international airport, the Airport City and the entire Municipality of Bulakan in the Province of Bulacan." Acknowledging the potential benefits of this project to uplift the socio-economic status of the surrounding areas and modernize air transport in the country, the construction of the international airport, and the creation of an ecozone in the area will further complicate the already stressed habitat and ecosystem of Manila Bay.

Figure 2-4: Artist impression of New Manila International Airport [8]

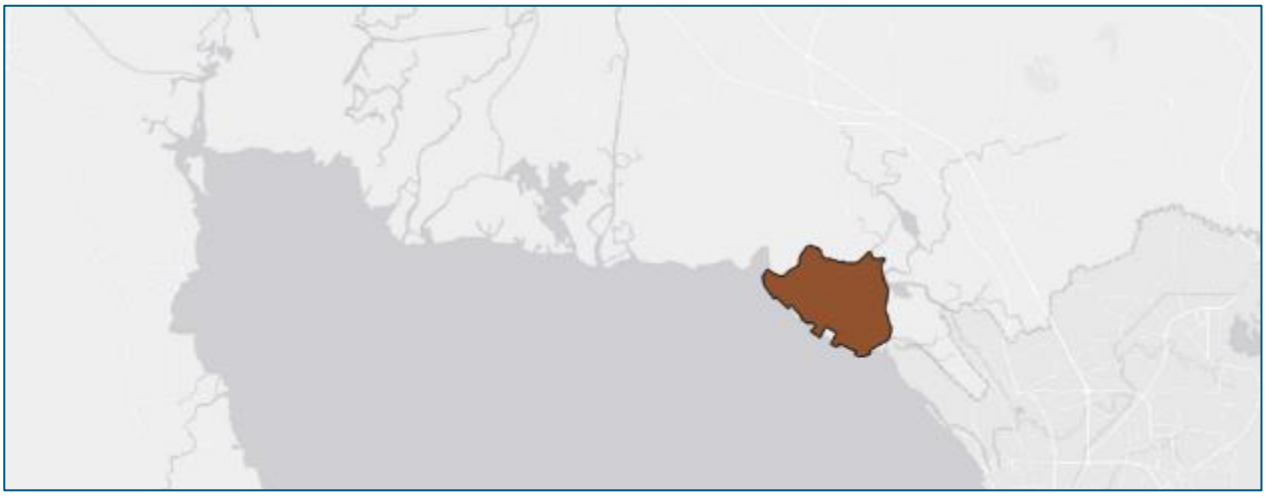


Figure 2-5: Location of the New Manila International Airport

Currently, dredging an access channel, which is needed for the airport reclamation works, has been completed, and river dredging around MIA is about to start. San Miguel Holdings Corporation contacted the Dutch company Royal Boskalis Westminster N.V. to conduct the dredging works. As part of international Environmental and Social Impact Assessment (EISA) requirements, the biodiversity and social impact of the airport needs to be offset. The impact on biodiversity mainly involves the feeding and resting areas of (migratory) waterbird populations, as well as the human population that lives in the airport area.

During the creation of the North Manila Bay Flood Protection Strategy, there was contact with both San Miguel Holdings Corporation and Royal Boskalis Westminster N.V.. No agreements on alignment or collaboration were made.

2.4.4 Angat, Pampanga, Pamarawan and Malolos River Dredging

During stakeholder meetings, it was mentioned that recently, permits have been issued for dredging the rivers in the North Manila Bay Delta. Various attempts have been made to get more information on the area, amount and volume of dredging allowed. At this point in time, it is only known that there are “permits issued”, which DENR R3 EMB/CMOB does not know of. The origin of these permits most likely lies within the LGUs or Provincial government.

3 Root cause analysis

This root cause analysis sets out the current physical, environmental and institutional characteristics that contribute to the flood-related issues in the North Manila Bay Delta.

3.1 North Manila Bay Delta characteristics

The study area of this flood protection strategy, the North Manila Bay Delta, consists of the downstream part of the rivers of the Pampanga River Basin, including the coastal area.

The area is a large alluvial plain with coastal wetlands downstream. The wider Pampanga River Basin has a catchment area of 10,000 km^2 [9]. The Pampanga River Basin can be roughly divided into three river systems:

- The Pampanga main river system has a basin of approximately 8,000 km^2. The river originates from the Caraballo Mountains and empties into Manila Bay.
- The Angat River system has a length of 165 km and a catchment area of approximately 1,085 km^2. The river originates from the Sierra Madre Mountains and empties into Manila Bay through the Labangan Floodway.
- The rivers in the Pasac river system originate from Mt. Pinatubo and flow into Manila Bay. The river system is connected to the Pampanga River by the Bebe-San Esteban Cut-off Channel. The total catchment area of the river system is about 1,371 km^2.

Figure 3-1: The Pampanga river basin (left, blue) [10] and the Pampanga Delta (right, red)

Near the river outflows, the coastal wetland areas are 0-1 meters above MSL and reach several kilometres inland. The upper parts of the delta are about 9 meters above MSL. Due to this relatively small elevation difference over the extent of the delta (20-30 kilometres), the North Manila Bay Delta is prone to pluvial (rainfall), fluvial (river), and coastal flooding. Decades of coastline expansion, sea-level rise, river flow narrowing, and rapid land subsidence in recent decades make the North Manila Bay Delta area even more vulnerable to flooding. This flood protection strategy will provide an approach to mitigate the fluvial and coastal flooding impacts in parts of the North Manila Bay Delta. It will also provide a basis for expanding the strategy towards other areas and solutions.

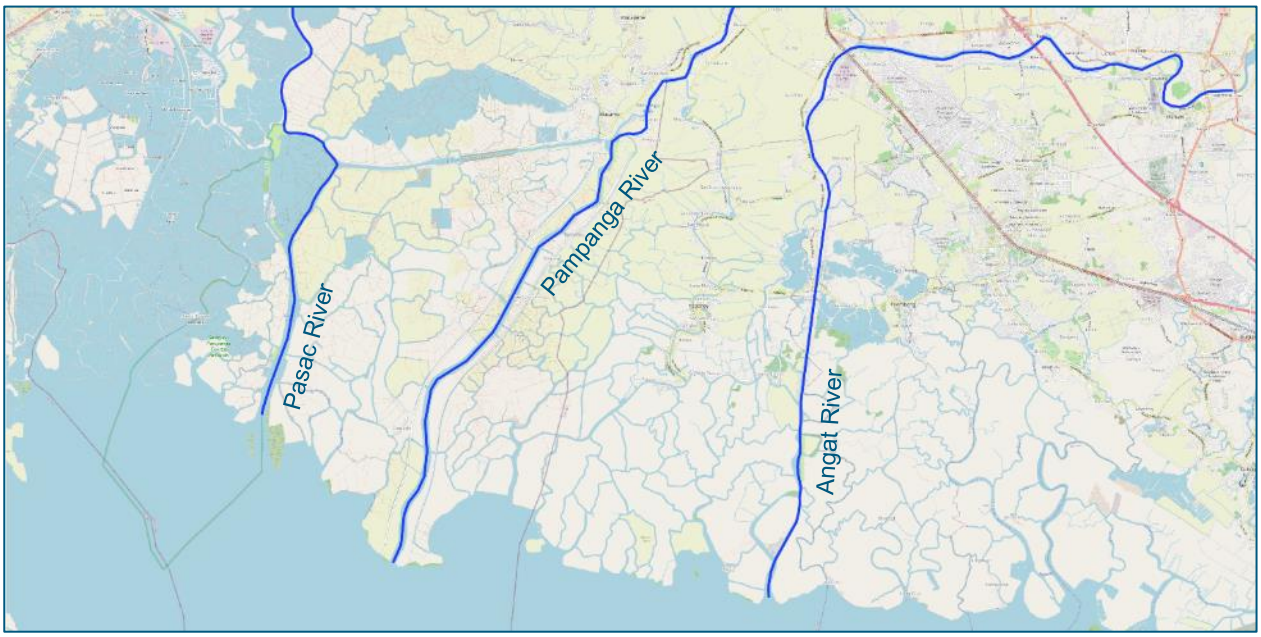


Figure 3-2: Three main rivers in Pampanga Delta

The North Manilla Bay Delta coast is tide-dominated, with some river-dominated features at the mouth of the Pampanga River. The tide is mixed, predominantly diurnal (one high and one low tide each lunar day), with an average tidal range of 1.2 m during spring and 0.4 m during neap tide [11]. Wind can also cause an increase in water levels in the bay. During the southwest monsoon (June-September), the tidal amplitude can be increased by 80% in the area. Furthermore, wind waves of over 3 meters may occur [12]. Tsunamis in the Philippines could be devastating, although only one has occurred in Manila Bay in the last 100 years. The relative sea-level rise rate in Manila Bay is on average 1.5 cm to 2.5 cm per year. In addition, the land is sinking in several areas; the land subsidence is caused by groundwater over-extraction [13].

The dry season runs from December to May and has average monthly precipitation in this area between 30 to 160 mm [11]. The wet season runs from June to November, and the average monthly rainfall ranges from 180 mm to 410 mm. Tropical cyclones with storms mostly occur during the wet season. Manila Bay is susceptible to storm surges; on average, the study area is affected by one to two storm surges per year related to cyclones [14]. At the peak of the cyclone period, rainfall can be up to 400 mm a day.

The substrate in Manila Bay ranges from mud to sand. The sediment is muddier near the river mouths, supplied by the rivers [15].

The four main wetland habitats in the North Manila Bay Delta coastal zone are fishponds, shallow foreshores, tidal flats, and mangroves (Figure 3-3). Wetland habitats decreased by 71% over around 125 years [16]. Fishponds (61.271 ha) were initially constructed in former mangrove areas but had been expanding into the shallow bay waters, mudflats and rivers [17]. In the 1970s, mangroves were converted to rice paddies, and since 1996 most of these rice paddies have been converted into fishponds due to extending saltwater intrusion caused by subsidence and rising sea levels. The fishpond expansion in the Pampanga Delta, about 15,000 hectares, took place over the past 40 years.

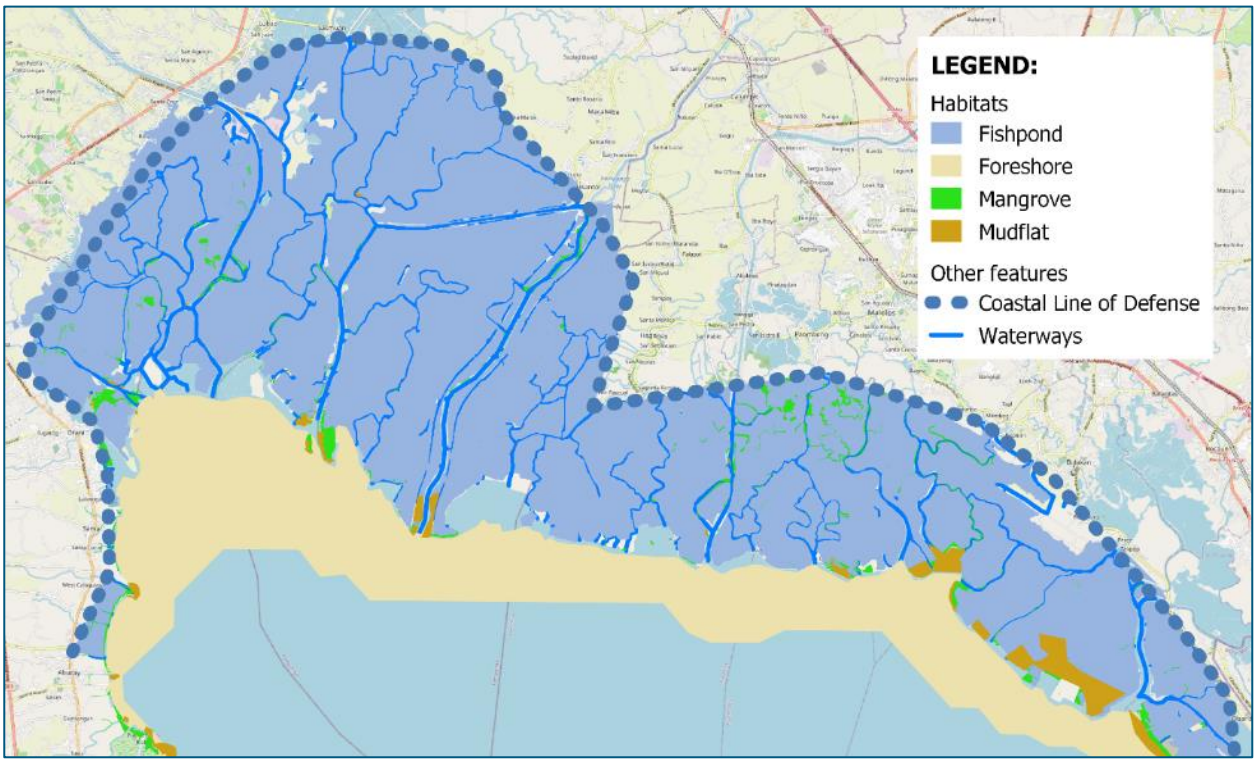


Figure 3-3 Distribution of wetland habitats in Manila Bay in 2017 [16].

Major population centres are:

- Bulacan

  The municipality of Bulacan lies in the southwestern part of the province of Bulacan. It has about 80,000 inhabitants and will be adjacent to the New Manila International Airport development. Due to the proximity of the airport development, it is expected that the characteristics of the area will change rapidly in the coming years. Therefore, Bulacan as a population centre is not included as a “priority location” in this flood protection strategy.

- Malolos

  Malolos is the capital city of the province of Bulacan. As such, the city hosts many provincial government offices. The city is home to more than 260,000 inhabitants, most of which reside in the urban areas in the northern part of the city. Meanwhile, the southern part of the city is situated near the coastline and predominantly consists of fishponds and intertidal areas..

- Calumpit

  The municipality of Calumpit is part of Bulacan province and lies along the border with Pampanga. It has a population of more than 118,000. It is a landlocked municipality and lies more than 10 km from the coastline of North Manila Bay. Thus, it is not considered a major priority location. However, it lies along major rivers, including the Pampanga River and Angat River, making the area prone to river flooding

- Hagonoy

  The coastal municipality of Hagonoy lies at the southwest corner of the province of Bulacan, south of Calumpit. It has more than 133,000 inhabitants, most of which reside in the northern part of the municipality. A few smaller population centres are situated along Manila Bay.

- Masantol

  Masantol is one of the municipalities at the southern end of Pampanga. It has a population of about 58,000. Population centres are primarily situated in three locations: the northeast corner of the municipality, along the stretch of Pampanga River, and the Bebe-Esteban Cutoff Channel.

- Macabebe

  The municipality of Macabebe has a population of more than 78,000. The northern part is home to most of the residents. Meanwhile, the southern part is largely occupied by fishponds which are major source of livelihood for the residents.

- Guagua

  The municipality of Guagua does not lie along Manila Bay as it is more than 15 km from the coastline. It has about 129,0000 inhabitants. The main population centre lies at the western part of Guagua while the remaining residential areas are scattered throughout the municipality. Farm fields occupy a larger portion of Guagua while fishponds occupy a smaller area.

- Lubao

  Lubao is one of the largest municipalities in Pampanga in terms of area. It has a population of more than 173,000. Most inhabitants reside at the northern part of Lubao which is farther from the coastline. The southern part of Lubao consists mainly of fishponds. A few villages are also situated near the coastline.

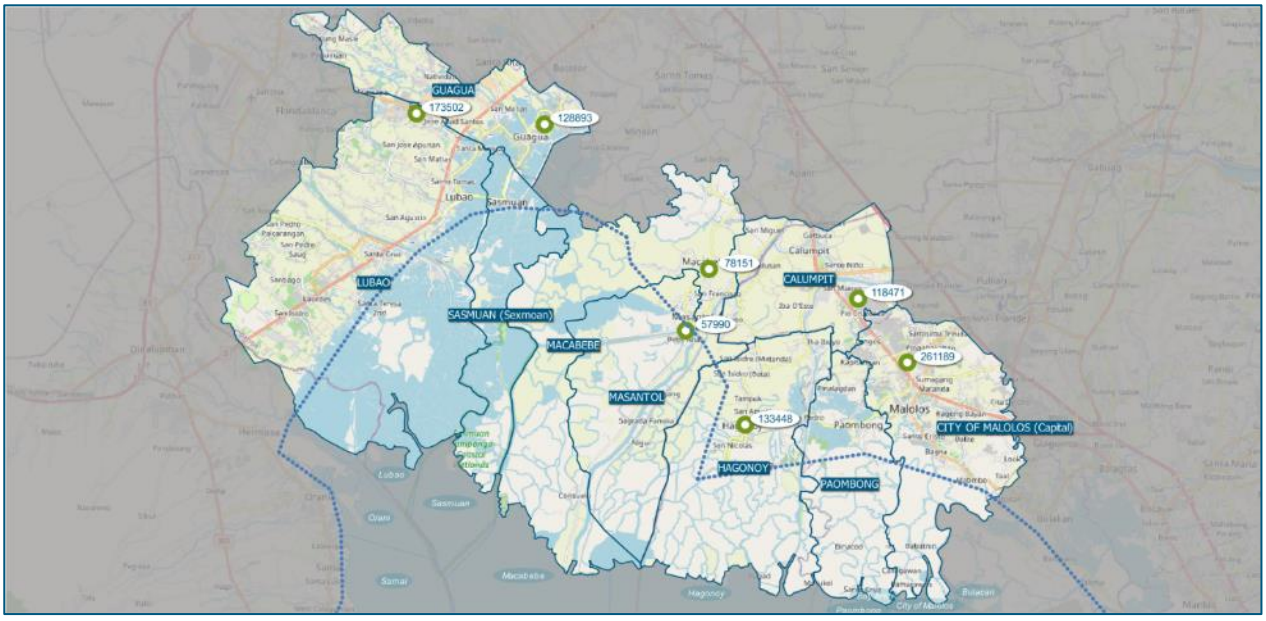


Figure 3-4: Population centres

3.2 Population expansion

As shown in Figure 3-5, the historic coastline of the North Manila Bay Delta lies north of several of the current population centres. It is estimated that 300,000 people live outside the historic coastline. Over the past decades, this expansion has been fuelled by rice paddies and fishpond expansions. It is one of the leading root causes of the flood risk in these areas; people have settled on historic wetlands/intertidal zones, which are supposed to be flooded. The recent subsidence and sea-level rise have magnified this problem.

By 2045, the Philippine Statistics Authority (PSA) projects that the country will have a total population of 142.10 million. These population projections are percentage-wise and also applicable for Region 3. In the census of 2020, Region 3 had a total population of about 12.5 million people.

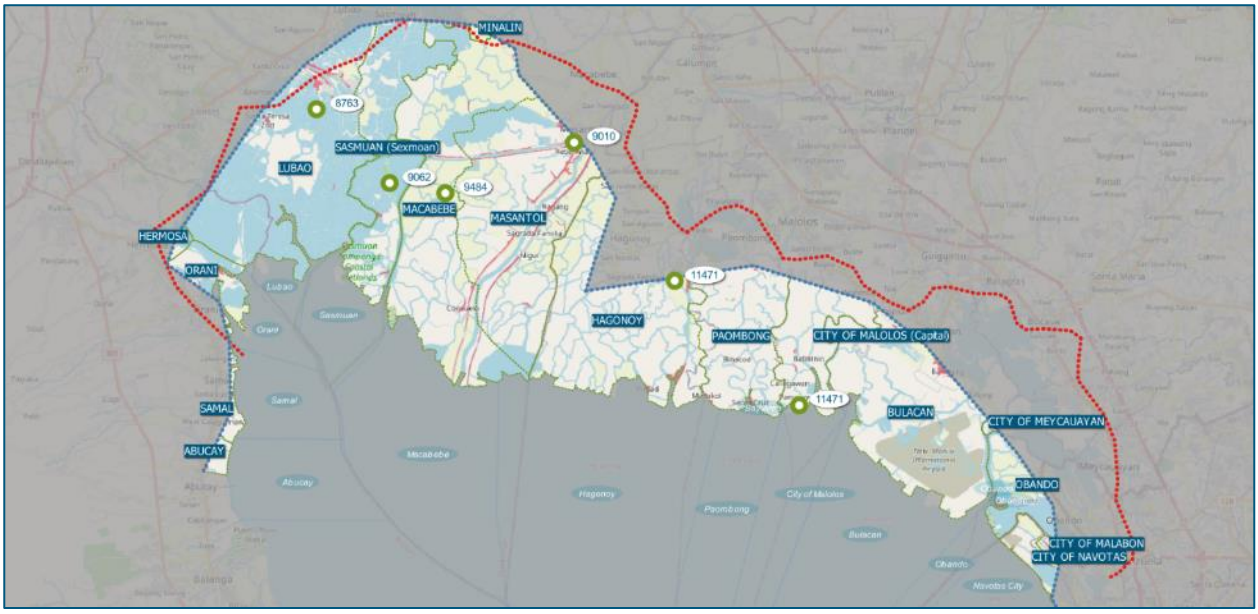


Figure 3-5: Historic coastline [18] (red) Coastal line of Defence (blue)

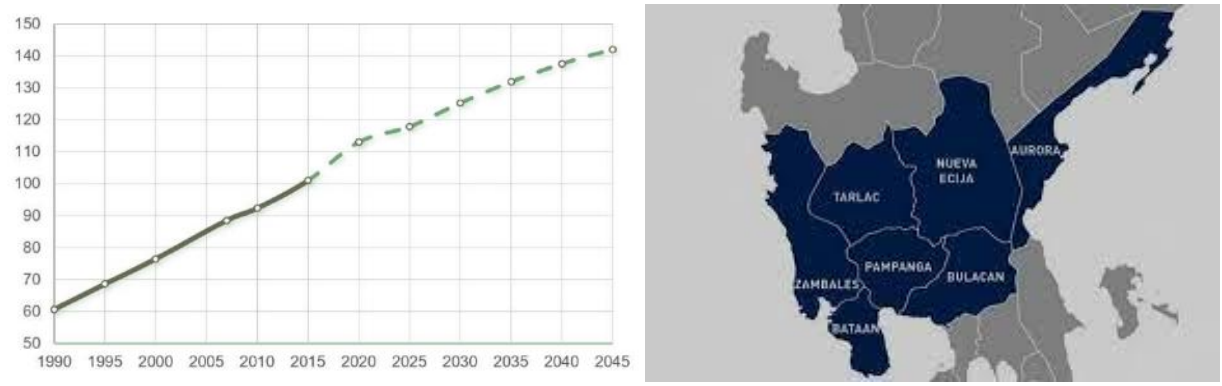


Figure 3-6: Left: Total Population projection of Philippines [2], and Right: Region 3

The Manila Bay Sustainable Development Masterplan [1] [2] created population growth models showing that the population north of Metro Manila will increase for the coming decades (Figure 3-7).

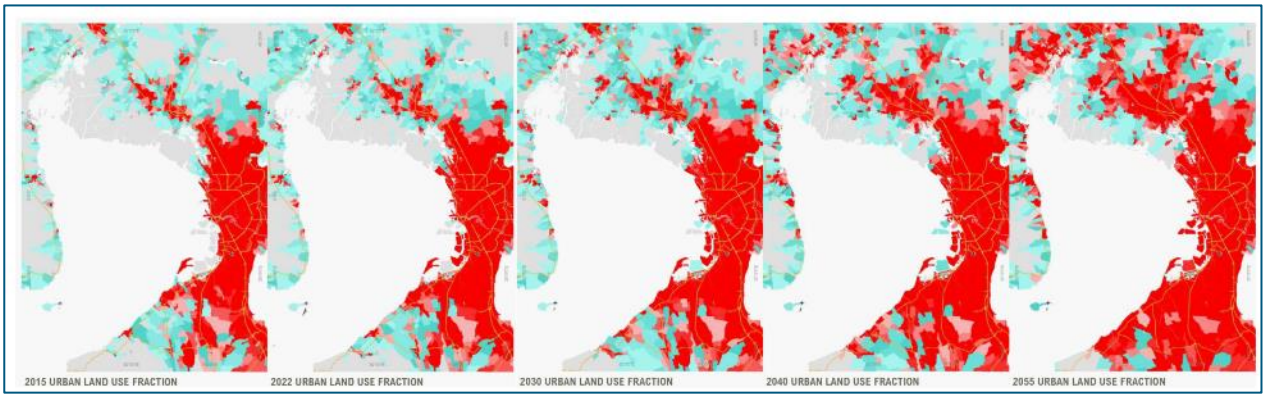


Figure 3-7: Population growth up to 2055

3.3 Decline of natural habitat

Wetlands and intertidal flats are valuable habitats and essential for coastal protection as well as livelihoods. Together, the combination of large areas with shallow waters, tidal flats, mangroves and unregulated rivers effectively mitigate impacts from tidal, typhoon, and river flooding. According to the International Guidelines on Natural and Nature-Based Features for Flood Risk Management, [19] wetlands, including intertidal flats, can deliver benefits in the following five ways:

- Reducing long-term shoreline erosion, which exacerbates future flood risk;
- Trapping and stabilizing coastal sediments, which contributes to coastal wetland surface elevation and land build-up, and consequently reduce future flood risk;
- Weakening the energy of a storm surge, and hence the height, of incoming waves, which reduces the total water levels, or the wave energy transmitted to habitats or structures landward of the wetland;
- Providing flood storage, which redistributes the total flood volume, thereby reducing flood damages in adjacent areas.

The North Manila Bay delta used to have large mangrove areas; its natural stage had more than 80,000 ha [18]. Mangroves are among the most productive ecosystems, and they provide a nursery function to various species of fish and other marine life and breeding places for waterbirds. Mangroves are also effective carbon sinks; they absorb carbon dioxide and convert it to oxygen through photosynthesis.

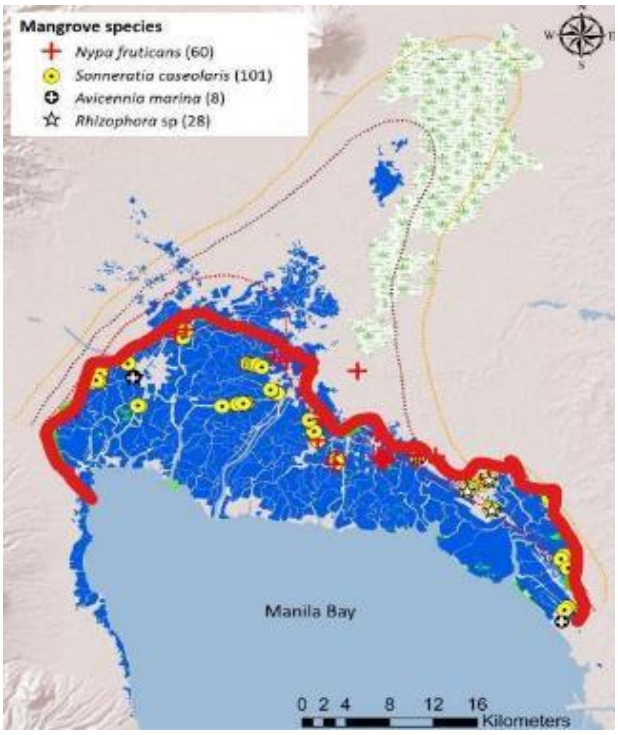


Figure 3-8: Distribution of historic mangrove species indicating the current high tide coastline (red line) [18]

The natural habitat made up of mangroves, and tidal flats capture the sediments coming from the rivers upstream, allowing it to grow together with any water level changes. With the natural habitat gone, the ability of the North Manila Bay to grow (to a certain extent) with rising sea levels and subsiding grounds is substantially reduced.

The original wetlands in the North Manila Bay Delta cover about 80,000 hectares. Within the 2-meter water column [16] they provide food and habitat for fish, waterbirds, and other wildlife, maintaining and improving the water quality of rivers, lakes, and estuaries, acting as a reservoir for watersheds, and protecting properties from potential flood damage. While there has been a very significant decline over time, the remaining tidal flats and shallow areas remain essential habitats for fish and benthic life forms necessary for livelihoods and for threatened migratory waterbird species and the functioning of the Manila Bay ecosystem.

The decline of the mangroves in North Manila Bay Delta is best described by Figure 3-8. Rollon et al. [18] did research into the distribution of mangrove species. Together with other spatial data, it can be concluded that the "old" coastline, the current saltwater hightide where fragments of mangroves still are present, can be indicated by the red line in Figure 3-8. This means that about 70,000 hectares of mangroves have

disappeared since the cultivation of the North Manila Bay Delta. There are few locations left with mangroves, as shown in Figure 3-9.

Figure 3-8 also indicates that the coastline (with a definition where the land meets high tide, hence where the historic mangrove presence would stop) has been pushed outwards by cultivating the mangrove and wetland areas into fishponds [20]. This subsequently means that the people living in these tidal exposed areas are vulnerable to flooding. Further construction of fishponds and dikes only worsens this situation.

Figure 3-9: Remaining mangroves areas North Manila Bay [2]

Figure 3-10: Coastal mangrove forest in Bulacan Photo: Arne Jensen (left) Christina Cinco (right)

Figure 3-10 shows some impressions of the remaining mangroves and coastal forest in the North Manila Bay delta. Besides the decline in mangrove areas, the mudflat areas have been replaced (mainly) by fishponds combined with conversion into mangrove plantations. Tidal mudflats are of huge environmental significance. They provide a food source for local people and are crucial feeding areas for migratory waterbirds, offer protection against incoming waves, and help tackle climate change by absorbing great carbon dioxide levels.

Figure 3-11: Tidal mudflat in Bulacan (Left) and sample of high-density mollusc bivalves in mudflats (right) Photo: Arne Jensen

Figure 3-12: Shallow waters with congregations of threatened migratory waterbirds in Bulacan and livelihood fishing area. Photos: Diuvs de Jesus (left) Jasmine Meren (right)

It can be concluded that 99% of the mangrove forest and about 80% of all tidal flats have been removed and converted into fishponds within a century. Next to that, all major rivers became regulated, impacting the sediment dispersion within said mangrove forest and tidal flats. Due to this, the coast North Manila Bay Delta is less protected against surges and wave attack, and the area has a negative sediment balance (due to less input and less sediment capture), which increases the problem due to erosion of the coastline.

A thesis study by ‘t Veldt [21] shows that the presence of the fishponds on the historic tidal planes causes flooding upstream. This is best illustrated by Figure 3-13, which shows numerical flood modelling results for 50-year subsidence/flooding scenarios. It was assumed that the fishponds will remain operational and “diked” for one scenario. It was assumed that the fishponds would be abandoned over time for the second scenario.

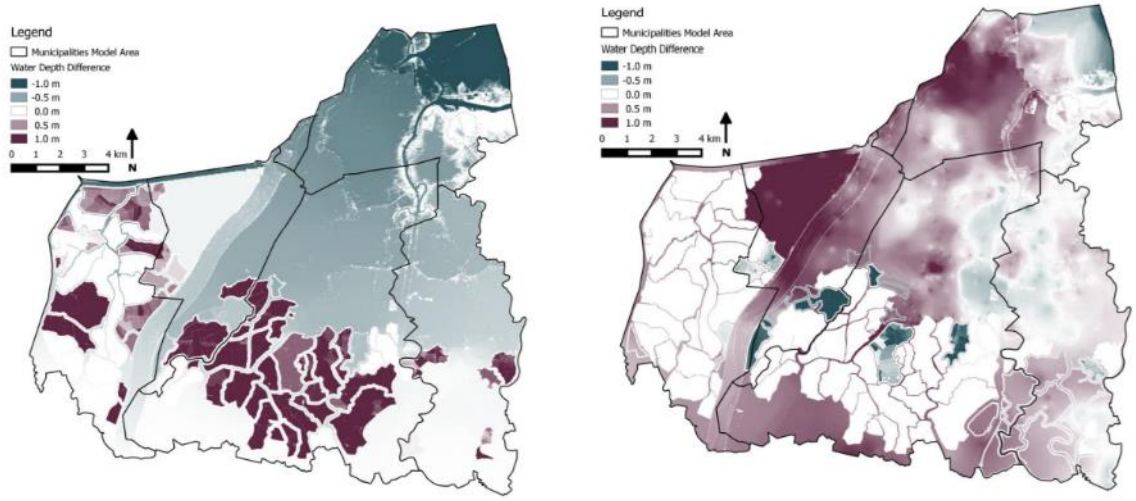


Figure 3-13: Fluvial flood scenarios 50 years [21] including subsidence; left "abandoned fishponds"; right with fishponds maintained

3.4 Storm surges

The layout of Manila Bay makes North Manila Bay Delta vulnerable to flooding due to storm surges during southwest wind directions [22] [23]. Studies on hindcast data show that water level elevations (storm surges) [22] could reach 2 meters MSL. However, it must be noted that all existing studies mainly focus on the Metro Manila area. Due to the layout of Manila Bay, it is expected that the storm surge can be higher when it reaches the coast under certain circumstances. With an expert judgment (based on various sources) on the extrapolation of the surge data, it is assumed that there is a significant chance that in the coming 100 years a storm surge of 3 to 4 m MSL could impact the area. This excludes additional set-up due to river discharge. Figure 3-14 shows the impact of such a surge. Surges like this will dominate the flooding of the area.

Such large storm surges have an enormous impact on the management of the coastal area. Typhoon Pedring in 2011 caused a storm surge of about 1.8 meters above the prevailing tide and reached tenths of kilometres inland in combination with high river discharges. It took months before the water drained out of the areas back to the sea. Local structures to protect fishponds and/or coastal communities were completely destroyed. Most fishpond owners, communities and local government did not have the means to restore what was there. In several places, the coastline retreated for hundreds of meters. Most of the area of the current NMIA was converted from land to sea.

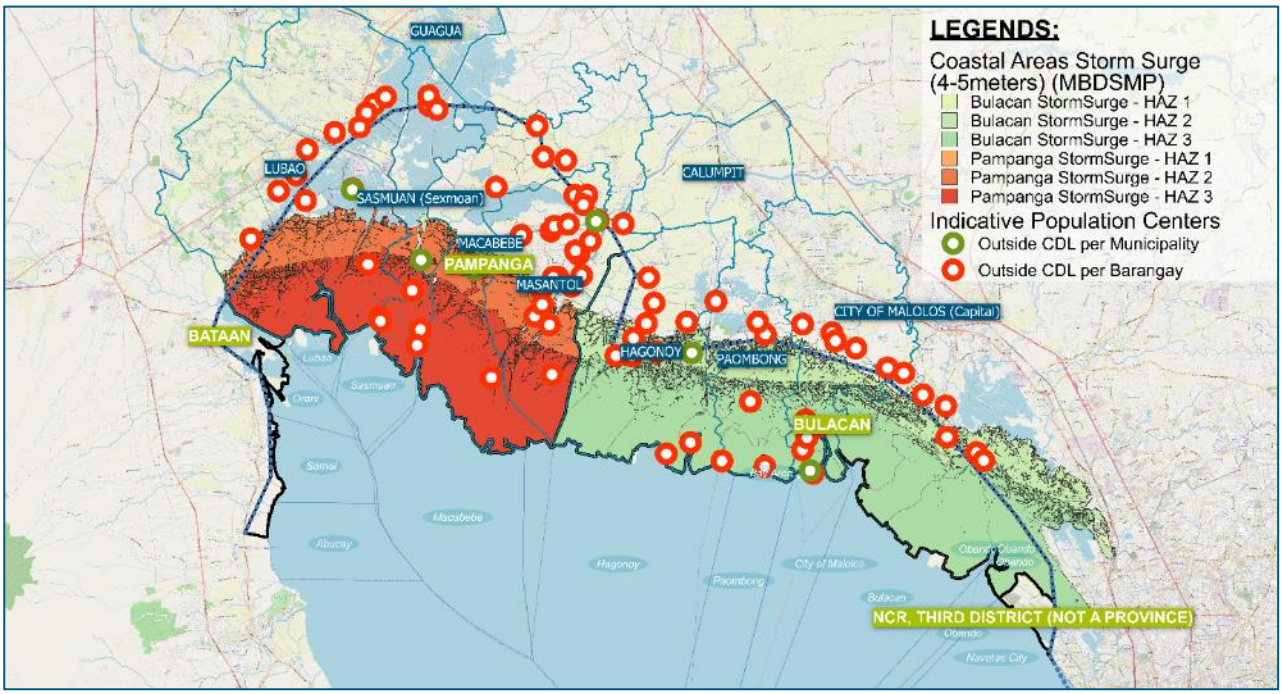


Figure 3-14: Flooded areas during a 4-meter storm surge

3.5 Erosion and sediment shortage

As discussed in Section 3.3, mangroves have largely disappeared and replaced man-made fishponds, pushing the original coastline into Manila Bay. Due to the loss of mangrove areas, the North Manila Bay Delta coastal area holds way fewer natural sediments than 70 years ago. This could mean:

- The sediments supposed to be deposited hindered from arriving in North Manila Bay Delta upstream of the rivers.
- Sediments are directly transported into Manila Bay due to the canalized rivers and therefore do not get a chance to deposit in the North Manila Bay Delta.
- Due to the removal of mangroves and the shortage of sediments, erosion is a frequently occurring problem. The pace of the process depends on both continuing events (sediment shortage) and instantaneous events (storm waves). The process impacts the current man-made structures in the area, as can be seen in Figure 3-15.
- The ongoing subsidence changed the erosion/sedimentation balance towards more erosion.

Figure 3-15: Examples of erosion of man-made structures.

3.6 Climate change

The Intergovernmental Panel on Climate Change (IPCC) was created to provide a regular scientific assessment of climate change. The biggest impact climate change will have on the North Manila Bay Delta is sea level rise, primarily caused by melting ice on the North and South Pole and due to the general heating of ocean waters. Besides sea level rise, climate change can also have an impact on intensifying rainfall events, typhoon tracks/durations and typhoon strength. This strategy only considers the sea level rise component of climate change in this strategy. The IPCC calculates possible sea-level rise based on Shared Socioeconomic Pathways (SSP) (Figure 3-16). SSPs provide narratives describing alternative socio-economic developments.

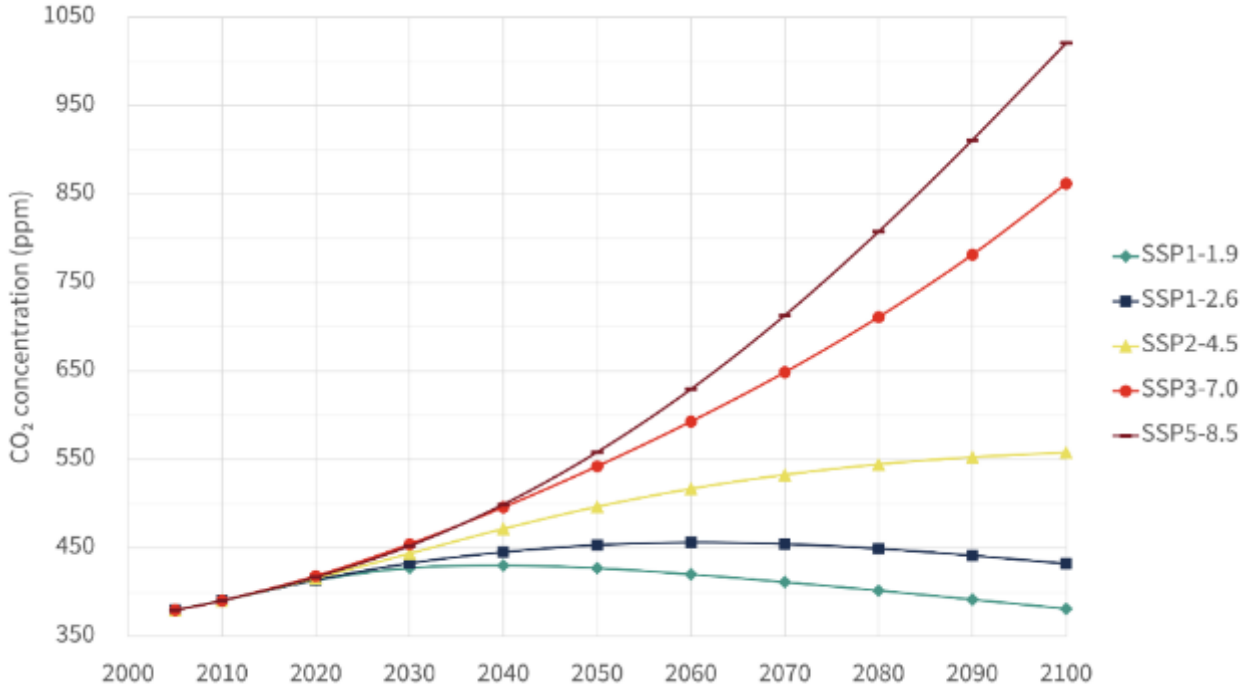


Figure 3-16: Representative Concentration Pathways [24]

Figure 3-17 shows the sea-level change for SSP scenarios resulting from processes whose projection is medium confidence. Two low-confidence scenarios are also provided, indicating the potential effect of low-likelihood, high-impact ice sheet processes that cannot be ruled out. Shaded ranges show the 17th-83rd percentile ranges. Projections are relative to a 1995-2014 baseline. The plot below shows the projection and uncertainties for 'Total Sea Level Change'.

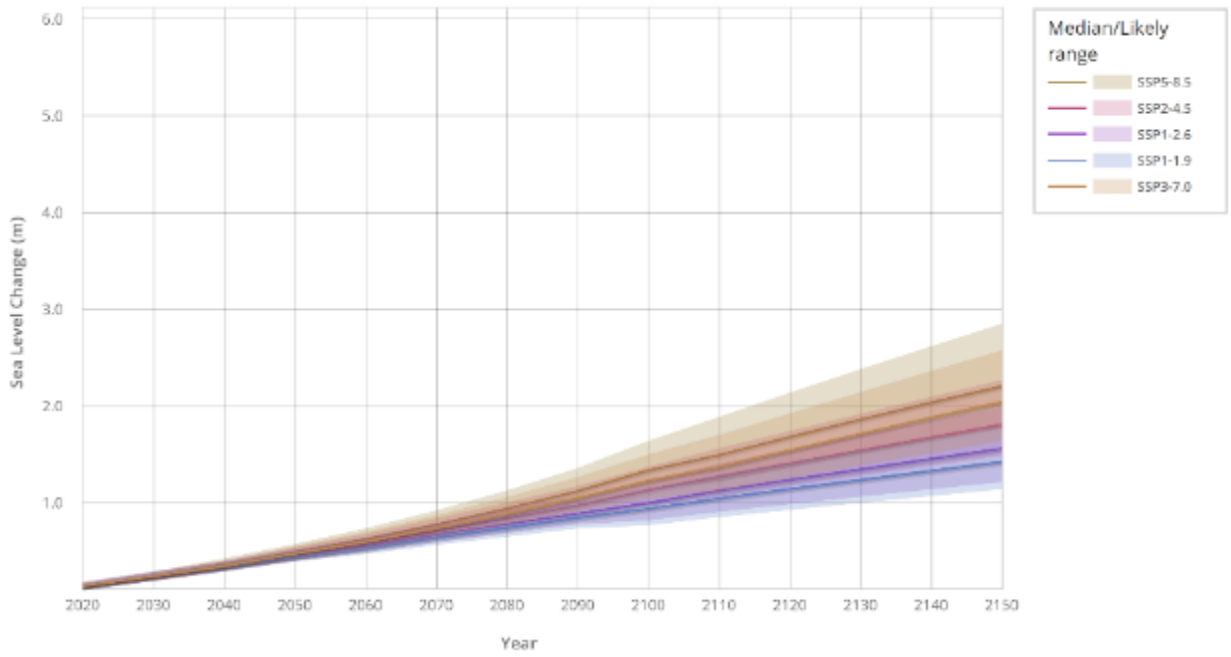


Figure 3-17: Sea level rise projection for Manila Bay South Harbor tidal gauge [25]

The relative annual sea level trend is 1.45 cm/year (+/- 0.7 cm based on mean sea level data from 1963 to 2017). This is equivalent to a 145 cm change in 100 years. Since 1963, the sea level in the Bay may have increased by 84 cm, and it will increase by around 30 cm in the next 20 years.

Looking 50 years ahead to the year 2070 for the most conservative scenarios, 0.9 m of plain sea level rise can be expected. If the current plans for reducing carbon emissions will have the most positive effect, a 0.6 m sea-level rise can still be expected.

3.7 Fluvial flooding

A fluvial or river flooding occurs when the water level overflows onto the surrounding banks and neighbouring land. The water level rise is primarily caused by excessive rainfall, but the highest water levels occur when the rainfall coincides with a storm surge compound flooding. The storm surge will limit the discharge capabilities of the river, further impacting the water level rise upstream.

The progressing cultivation of the mangrove areas and conversion of tidal flats adjacent to rivers, the canalization of the rivers, and restrictions of the natural river flow in the form of narrow dikes and fishpond expansion have reduced the discharge and storage capacity of the river systems as there is less space for the water to flow. Due to the low discharge capacity, flood levels are higher, and surrounding areas become more prone to flooding. The canalization of river channels also hampers frequent sedimentation in areas adjacent to the river. This reduction in sediment supply reduces the ability of the natural delta system to increase in elevation and grow with sea-level rise. Dredging below sea level also affects flooding as it leads to backwaters when water levels are high.

Figure 3-18: Examples of river canalization in the North Manila Bay Delta (Angat River and Pampanga River)

3.8 Local Rainfall

Road and riverbank elevation (to compensate for subsidence) without proper adjustments of the local drainage systems has led to water clogging in many places within the study area. Local rainfall fills the lower areas between the elevated roads and river banks, some of which remains water-logged or flooded for weeks. Moreover, the sea level in the lower parts of the delta has become relatively higher due to subsidence, thereby losing the gravity drainage even during most low tides. To date, no large pumping schemes have been implemented in the study area to solve this problem.

3.9 Land subsidence

Land subsidence resulting from excessive groundwater extraction is a well-recognized phenomenon in the Philippines today but largely unstudied in the North Manila Bay area, even though land subsidence in many areas contributes to flooding more than the sea level rise. The Manila Bay Sustainable Development Masterplan [1] recognizes this problem and translated some studies into a quantitative assessment shown in Figure 3-19. The red areas indicate a land subsidence rate of 20-50 cm a year and the green areas 7 to 13 cm a year.

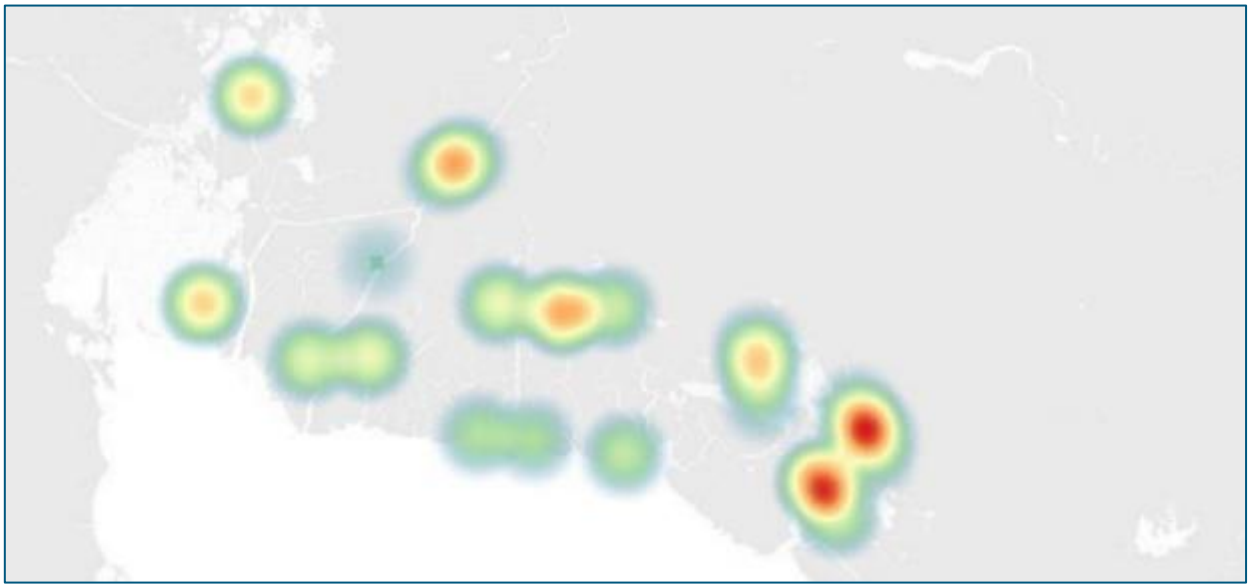


Figure 3-19: Land subsidence in North Manila Bay [2]

The Manila Bay Sustainable Development Masterplan states:

"With the rate of land subsidence plus sea-level rise at the north of Manila Bay, any flood protection measure or development project initiated now are likely to become dysfunctional within the next decades. With the rate of population growth and expansion in these areas, addressing the concerns of communities on being exposed to flooding has become more complicated and difficult to manage."

Groundwater extraction is the major driver for land subsidence in the North Manila Bay Delta. Various literature concluded that even if groundwater use is significantly reduced, the natural deltaic subsidence and global sea-level rise will continue to increase the flooding exposure of the North Manila Bay Delta. As drawn from Figure 3-20, sea-level rise and groundwater extraction peaked over the last decades.

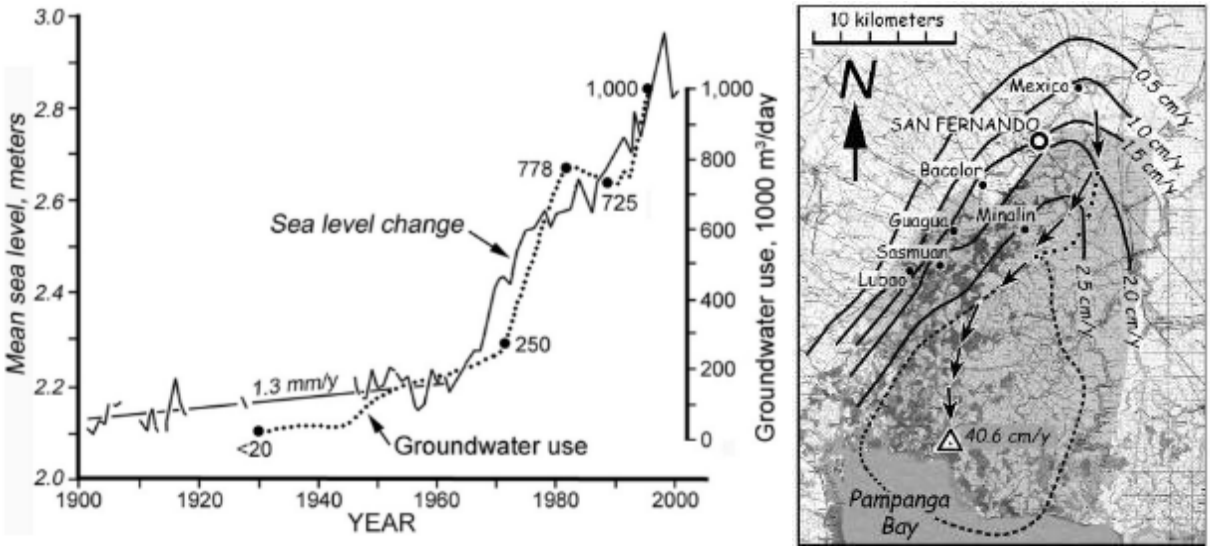


Figure 3-20: Sea level rise vs. groundwater usage and subsidence in North Manila Bay [26]

3.10 Sediment extraction

The Philippines is a rapidly developing country, and the need for building materials is higher than ever. Due to the increasing demand for building materials, quarry permits and concessions are highly sought. In addition, new policies now allow for large-scale commercialised sediment dredging of rivers and river mouths that disrupt the natural build-up of new coastal lands and risk causing further erosion in the study area, see Section 2.4.4.

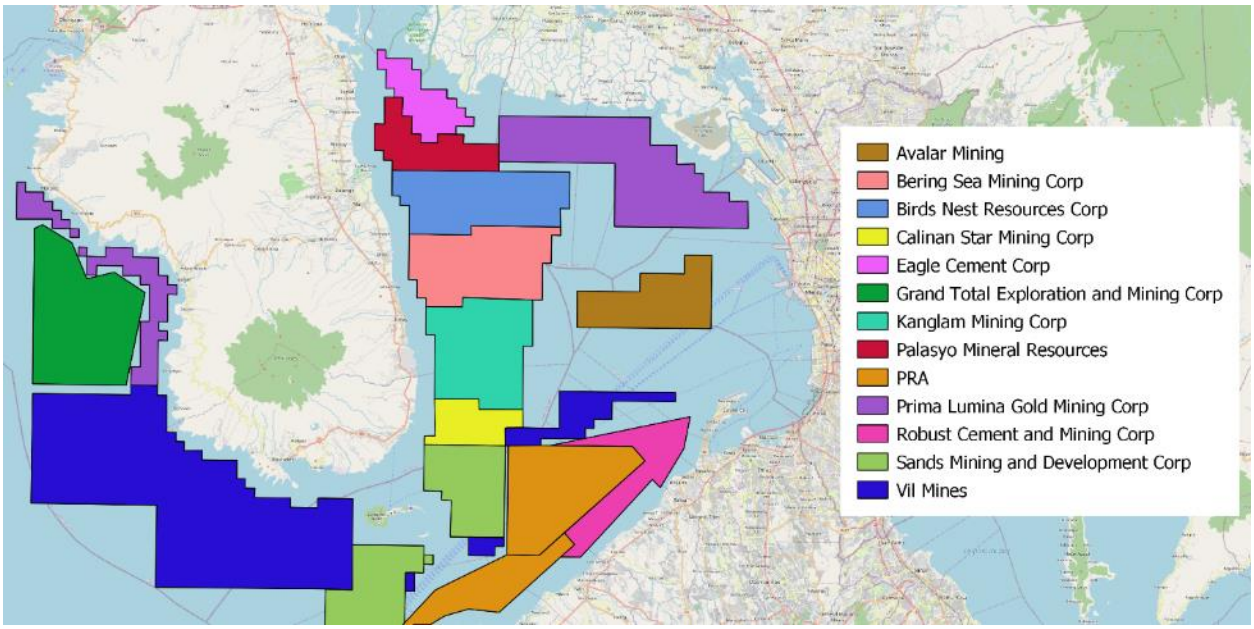


Figure 3-21: Overview of seabed mining concessions in Manila Bay

Figure 3-21 shows several mining concessions close to the North Manila Bay Delta coastline. These concessions entail the extraction of marine sand, aggregates and other minerals. It is not clear when the concessions will be activated. But when these areas are mined, the seabed will transform (will become deeper), leading to a disturbance of the current morphological layout of the North Manila Bay Delta. Impacts could be:

- Increased wave heights due to the deeper seabed, leading to increased erosion;
- Increased erosion due to soft sediments flowing into the deeper dredged areas;
- Higher surge levels, increasing flood levels;
- Impact on livelihood and nature, for example, the fish stock, Figure 3-22.

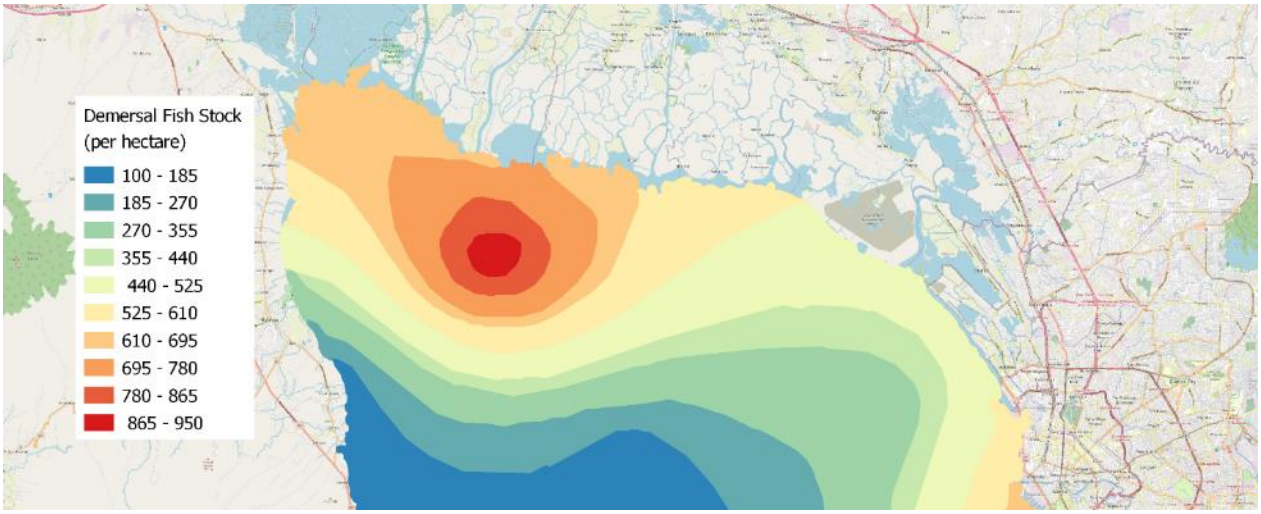


Figure 3-22: Demersal fish stock in North Manila Bay

Furthermore, it is known that dredging permits for the Angat, Pamarawan, Malolos and Bulacan rivers have been issued. At this point, no ECC/EIS documents have been shared by DENR EMB, MGB or local LGUs. Improper dredging of these rivers could lead to adverse effects. Various sources also confirmed that there

is a mining concession between the current coastline and the Prima Lumnia concession, as shown in Figure 3-21. At this point in time, DENR MGB could not confirm whether these permits had been issued by MGB or local LGUs.

4 Stakeholders

The stakeholder engagement for the North Manila Bay Flood Protection Strategy aims to engage the stakeholders in a meaningful way, considering their aspirations, sentiments, and recommendations at different project stages. Specifically, the plan aims to:

- Inform the stakeholders about the project, how they will be engaged, and how their inputs will be used; and
- Solicit the stakeholders' inputs in identifying and assessing the following:
  - Areas or area clusters for study;
  - Nature-based flood protection measures; and
  - Pilot locations

The stakeholder engagement for this project is premised on the principle that people and entities affected by the North Manila Bay Flood Protection Strategy have a right to be involved in the decision-making process. By recognizing, communicating, and reflecting the interests and needs of the different stakeholders, sustainable decisions are ensured. The stakeholder engagement provides opportunities for a wide range of stakeholders to:

- Understand and support the project;
- Share their needs, knowledge, and views on flood protection;
- Transfer knowledge on Nature-based Solutions, and the benefits derived from these;
- Participate in the process of identifying and developing flood protection strategies and selecting the pilot area(s); and
- Promote practical cooperation among concerned entities and potential implementation partners.

The stakeholder engagement has been divided into stages that are executed in chronological order but can be overlapping/updated during subsequent phases. In engaging with the stakeholders, the process was guided by the following three principles:

Table 4-1: Stakeholder engagement principles

1	**Open, inclusive, transparent, and respectful consultation**
The North Manila Bay Flood Protection Strategy recognized that different stakeholders had different interests and concerns that had to be respected. By including the affected stakeholders, varied interests and needs were considered and represented in decision-making. The purpose of each gathering was to be made transparent to avoid raising wrong expectations that the consultations or the Project cannot meet. Transparency in the engagement process, particularly how decisions were arrived at, helped build trust and commitment and helped ensure buy-in of the process and outputs.	
2	**Online meetings supplemented by face-to-face meetings**
The advantages of face-to-face interaction cannot be overemphasized. They promoted clearer understanding due to the ability to explain messages thoroughly and derive instantaneous feedback since anyone can step into the conversation to clarify or follow up on specific points. Face-to-face interaction also enhanced credibility and trust since everyone was able to see nonverbal cues (i.e., body language) and genuine reactions throughout the process. However, because of the worldwide COVID-19 crisis, a practical online approach was developed. Most of the meetings were conducted online using appropriate digital platforms. Online sessions included interaction with government agencies, local government officials, NGOs, and academic institutions. These types of stakeholders are used to speaking out in public, possess the required digital technology, and are familiar with the use of such technology. Online meetings were designed to allow everyone to comment and articulate their sentiments through appropriate engagement methods.	

For fishermen's groups, face-to-face meetings were preferred whenever feasible and allowed by health and safety protocols set by national and local governments. Unlike the first group of stakeholders discussed above, the fishermen do not possess the required technology or have access to communication that would allow them to participate in virtual meetings. To help ensure their participation in a meaningful and productive manner, the best scenario was to engage them face-to-face in their communities where they felt most comfortable.

3 Different types of engagement used for different types of stakeholders and purposes

Special attention was given to marginalized stakeholders who will most be affected by the implementation of flood protection strategies, such as the fishing communities in Bulacan and Pampanga's coastal areas. Different engagement methods were used depending on the stakeholder type and purpose of the engagement.

4.1 Stage 1: Identification of Stakeholders

The stakeholders engaged by the North Manila Bay Flood Protection Strategy are classified into three groups:

1. Government - refers to national and sub-national government units and entities
2. Private sector - refers to private sector firms and businesses
3. Civil society - refers to the sphere of public activity outside of government and private sector, including academe and local, community-based, and international NGOs.

4.1.1 Government

The engaged stakeholders from the government include the following:

Table 4-2: Identified government stakeholders

Stakeholder		Description
	Local Government Units (LGUs)	LGUs oversee local governance and administration in the provincial, city/municipal, or barangay level. LGUs are mandated with authority, responsibilities, and resources with the objective of providing direct services to the people and communities. Identified stakeholders are the respective LGUs of Malolos City, municipalities of Hagonoy, Paombong, and Calumpit in Bulacan province, and the municipalities of Masantol, Macabebe, and Lubao in Pampanga
	Alyansa ng mga Baybaying Bayan ng Bulacan at Pampanga (ABB-BP)	ABB-BP is an alliance composed of coastal cities and municipalities in Bulacan and Pampanga, including Malolos, Calumpit, Hagonoy, Paombong, Bulakan, Obando, Masantol, Macabebe, Lubao, and Sasmuan in Pampanga.
	Department of Public Works and Highways (DPWH)	DPWH is an executive government department mandated to undertake the planning, design, construction, and maintenance of national roads and bridges, major flood control systems, and water resources projects. Identified stakeholders are DPWH Planning Office and DPWH Region 3 Office.
	National Economic and Development Authority (NEDA)	NEDA is a cabinet-level government agency responsible for socioeconomic development and planning. It is mandated to conduct macroeconomic forecasting and policy analysis and research. Identified stakeholders are NEDA Central Office and NEDA Region 3 Office.
	Department of the Environment and Natural Resources (DENR)	DENR is the primary government department responsible for the conservation, management, development, and proper use of the country's environment and natural resources. Identified stakeholders are DENR - Manila Bay Coordinating Office (MBCO), DENR Region 3 Office, DENR Environmental Management Bureau (EMB), DENR Mines and Geosciences Bureau (MGB) and DENR Biodiversity Management Bureau.
	Bureau of Fisheries and Natural Resources (BFAR)	BFAR is an agency under the Department of Agriculture. It is responsible for the development, improvement, management and conservation of the country's fisheries

Stakeholder		Description
		and aquatic resources by virtue of Republic Act No. 8550 (Philippine Fisheries Code of 1998)

4.1.2 Private Sector

The following stakeholders are identified:

- San Miguel Corporation is the developer of the New Manila Bay Airport reclamation.
- Royal Boskalis Westminster N.V. is the dredging contractor for the New Manila Bay Airport reclamation

4.1.3 Public/Civil Society

The following stakeholders are identified:

- Fishermen's Associations
- Fishing vessel operators
- Fishpond operators
- Wetlands International Philippines
- People's Survival Fund
  (government entity linked to Climate Change Commission, Republic Act 10174)

Table 4-3: Summary of Stakeholders, Mandates, Interests, and Resources

Stakeholder	Mandate	Interest	Resources
Government			
LGU along the coast of Manila Bay	Provide essential services to citizens under the 1991 Local Government Code.	Stake in the provision of essential services, public safety, and project benefits accruing to constituents	Internal revenue allotment (IRA); Tax revenues
LGU members of ABB-BP	Address the problems of flooding and rising sea levels caused by the ill effects of climate change and global warming.	Stake in the provision of essential services, public safety, and project benefits accruing to constituents	Internal revenue allotment (IRA); Tax revenues
DPWH Planning Office	Member of 13 government agencies ordered by the Supreme Court through a Writ of Mandamus (hence called Mandamus agencies) to clean up, rehabilitate and restore the waters of Manila Bay to a quality fit for swimming and bathing. Approve funding for infrastructure projects. Under AO 16 creating the Manila Bay Task Force of which DPWH is a member, DPWH is mandated to implement programs and projects for flood control and drainage services, including dredging water bodies in areas outside of Metro Manila that is discharging into Manila Bay.	Stake in the provision of public infrastructure, including flood protection Alignment of projects to the DPWH's infrastructure plan	Agency budget; Congressional funds
DPWH Region 3 Office	Deliver a list of projects to the Central Office for funding consideration.	Stake in the provision of public infrastructure, including flood protection	Agency budget; Congressional funds

Stakeholder	Mandate	Interest	Resources
	Collaborate with other agencies such as DENR, DILG, and DOTr, especially on river dredging projects.	Alignment of projects to the DPWH's infrastructure plan	
NEDA Central Office	Member of 13 Mandamus agencies Member of Manila Bay Task Force	Alignment of projects to regional and national development goals and plans	Agency budget
NEDA Region 3 Office	Evaluate proposed projects through the Regional Development Council.	Alignment of projects to regional and national development goals and plans	Agency budget
DENR-MBCO	Created to support the 13 Mandamus agencies. DAO 2011-01 provided MBCO with a coordinative function (no oversight function) among all offices and agencies involved in Manila Bay's rehabilitation, restoration, and conservation. Lead in planning, monitoring, and reviewing all related activities and their press, and preparing reports required by the DENR and the Supreme Court.	Alignment of projects to the Operational Plan for the Manila Bay Coastal Strategy (OPMBCS)	Agency budget
DENR-EMB	Monitor environmental parameters to support DENR's objective of ridding Manila Bay of toxic and hazardous substances.	Stake in keeping Manila Bay free from toxic and hazardous substances Monitoring parameters (e.g., dissolved oxygen, pH level, grease, oil, and nutrients) in different sections of Manila Bay	Agency budget
DENR-Region 3 Office	Support the 13 Mandamus agencies	Alignment of projects to the Operational Plan for the Manila Bay Coastal Strategy (OPMBCS)	Agency budget
BFAR	Develop, improve, manage, and conserve fishery and aquatic resources. Under AO 6, assist LGUs in Bulacan, Pampanga, Bataan, Metro Manila, Rizal, Cavite, and Laguna in developing the fisheries and aquatic resources in Manila Bay using recognized methods.	Effect on fishery resources and productivity and fishermen's livelihood and income Align projects to the Operational Plan for the Manila Bay Coastal Strategy (OPMBCS).	Agency budget
Civil Society			
Fishermen's Association	Provide services to its members, including lending and livelihood.	Effect on fishery resources, livelihood, and income	Membership fees/dues; Donors
International and national NGOs whose interests align or who consider themselves as representatives of impacted people	Provide beneficiaries with technical, social, livelihood, capacity building, and funding support. Conserve the environment and natural resources. Implement initiatives on resilience and disaster preparedness.	Effect on community's well-being and the environment	Donors

4.2 Stage 2: Stakeholder engagement and information sharing

The stage of engagement, information generation, and data sharing occurs at the initial part of the Project. During this stage, the Project is introduced to the stakeholders, requests for secondary data such as relevant plans and projects in North Manila Bay are made, and ways to generate additional information are discussed. Stakeholders are recognized as significant sources of secondary and field-based data.

An initial stakeholder consultation workshop was held in September 2021 to provide an overview of the project for government agencies and LGUs, introduce officials/key personnel and project team members, enjoin their cooperation, and request for initial data and inputs.

Table 4-4: Stage 2 Stakeholder meetings

Activity	Summary	Date	Ref.
Stakeholder Consultation Workshop (online) with NEDA, BFAR, DENR, DPWH, ABB-BP	Provide an overview of the project for key stakeholders, introduce officials/key personnel and consultant team members, request for initial data	30-Sep-21	[27]

4.3 Stage 3: Consultations, feedback, and interest

4.3.1 Meeting with Stakeholders

Small one-on-one meetings were used to engage with stakeholders to discuss ongoing and planned projects in North Manila Bay, align similar initiatives, share data, discuss findings of the project team, recommend nature-based solutions and pilot locations, and explore implementing and funding arrangements.

The following table shows the highlights of the meetings held.

Table 4-5: Meetings held in Stage 3

Date	Activity	Objectives	Salient Points of Discussion	Ref.
8 Oct 21	Meeting with Boskalis	Discuss alignment of initiatives in the North Manila Bay area, flood protection measures, data sharing	There is principal alignment between the "BwN landscape proposition" project and Boskalis EIS efforts. Boskalis is interested in combining the NMIA project with coastline restoration but is uncertain whether the current dredged materials can be used due to time constraints. Boskalis doubts if restoring mudflats with dredged materials is efficient (financially) as it is hard to reach the shoreline with jumbo dredging vessels (draught 13 meters). The Biodiversity Action Plan for NMIA will be finished soon. It is unclear whether San Miguel will publish it publicly. DENR is making its own biodiversity offsetting plan for NMIA.	[28]
13 Oct 21	Meeting with NEDA Region 3	Discuss NEDA's ongoing and planned projects in the North Manila Bay area, data sharing	Projects in North Manila Bay Area: The New Manila International Airport is currently undergoing assessment by NEDA. Interphase with Other Agencies: All projects should pass through the Regional Development Council (RDC).	[29]
20 Oct 21	Meeting with DENR-MBCO	Discuss ongoing and planned projects in the North Manila Bay area, interphase with other government agencies, requirements and permits needed from DENR	Projects in North Manila Bay Area: Dredging is ongoing in Marilao under the initiative of DENR and Tullahan RIver by San Miguel Corporation. Mangrove planting is ongoing in Bulacan and Bataan, under DENR-Region 3. Dredging in Manila Bay is already complete. DENR is planning to dredge the Meycauayan River in 2022. Interphase with Other Agencies: DENR coordinates with the 13 mandamus agencies through their regional offices. Flood control projects are with DPWH due to the Mandamus. The Integrated Coastal Zone Management Plan for Region 3 is available. The EMB issues the EEC for dredging. The EMB should assess the dredged materials before disposal. The Philippine Coast Guard issues the Permit to Dispose. Dredged materials are disposed of in the West Philippine Sea.	[30]
21 Oct 21	Meeting with ABB-BP	Discuss ongoing and planned flood protection projects in member LGUs	Projects in North Manila Bay Area: Each municipality has its own plan.	[31]

Date	Activity	Objectives	Salient Points of Discussion	Ref.
			There is a road upgrading project in Hagonoy, Bulacan, and small river walls from other LGUs. DPWH is currently constructing a dike project in Paombong, Bulacan. There is ongoing dredging of the Meycauayan River in connection with the NMIA undertaken by SMC. There is no plan encompassing the coastline of Pampanga and Bulacan and no centralized flood protection projects for ABB-BP LGUs. Interphase with Other Agencies: BFAR, DENR, DPWH, NEDA, and ABBP-BP are key stakeholders in the flood protection project. DWPH Region 3 is the primary implementor for flood protection projects. Suggestion to identify priority LGUs instead of coordinating with all 10 ABB-BP members LGUs. Suggested priority LGUs: Calumpit, Hagonoy, Masantol, and Macabebe. Malolos Mayor is also amenable to implementing a flood protection project.	
26 Oct 21	Meeting with DPWH Central Office	Discuss DPWH's ongoing and planned projects in the North Manila Bay area, interphase with other government agencies, data sharing	Projects in North Manila Bay Area: DPWH Region 3 is currently implementing the Pampanga River Delta Project Masterplan. DPWH submitted an unsolicited proposal from SMC to NEDA Investment Coordination Committee (NEDA-ICC) on the Manila Bay Expressway. The project was put on hold due to non-compliance with ECC components. DPWH solicited a San Miguel Corporation (SMC) proposal on the Integrated Airport Toll Expressway Network (IATEN). DPWH will confirm the progress of the dike project in Masokol, Bulacan, under the TRAIN Program. RHDHV is willing to collaborate if the project is ongoing and if a redesign of the dike can be considered. DPWH Region 3 will request a list of projects from Unified Project Management Office – Flood Control Management Cluster (UPMO-FCMC), particularly for Bataan and Pampanga, to share with RHDHV. DPWH has not identified any significant projects within the Manila Bay Area. DPWH Region 3 & 4-A have small-scale projects related to tributaries discharging to Manila Bay. Interphase with Other Agencies: All DPWH projects are centralized and sent to the central office for funding considerations. Usually, projects are based on masterplans. DPWH will conduct an assessment in alignment with the masterplans. There are also instances where LGUs and other government agencies initiate projects. Under the Manila Bay Mandamus, MMDA is the lead agency for Manila Bay Rehabilitation projects.	[32]

Date	Activity	Objectives	Salient Points of Discussion	Ref.
			According to DWPH, in Region 8, nature-based solutions were seen as helpful compared to the usual engineering projects experienced during Typhoon Yolanda.	
4 Nov 21	Meeting with DENR Region 3	Discuss ongoing and planned projects in the North Manila Bay area, interphase with other government agencies, permitting processes, data sharing	Projects in North Manila Bay Area: In Hagonoy, Bulacan, DENR Region 3 proposed an 80-hectare mangrove plantation and rehabilitation program. The challenge encountered in the area is the sea level rise. They also confirmed that there are already mangroves in the navigation channels of their fisherfolks. DENR Region 3 conducted a feasibility study, in collaboration with MGB Region 3, to develop a silt containment area for shoreline nourishment in Masukol, Paombong, Bulacan. The facility has an area ranging from 65 to 73 hectares with an estimated cost of less than Php 50 million. The project is still currently being presented to potential contractors and the main office for funding approval. DENR-EMB conducts monthly water quality monitoring in the coastline to track the faecal coliform level and other parameters. Interphase with Other Agencies: In securing ECC, the proponents are required to conduct public consultations. DENR-EMB is the responsible agency in ECC issuance. DENR Region 3 confirmed that there is no declared environmentally critical area (ECA) in the foreshore area of Manila Bay. For funding purposes, the proposed project of RHDHV should first be presented to the DENR regional office. The regional office in turn will endorse the project to the DENR main office for approval. The permit issuance is dependent on the project cost since the regional office has limits, and for large projects, permits will be secured from the main office.	[33]
5 Nov 21	Meeting with DPWH Region 3	Discuss ongoing and planned DPWH projects in the North Manila Bay area, interphase with other government agencies, permitting processes, data sharing	Projects in North Manila Bay Area: In 2020, DPWH Region 3 constructed revetment works in Paombong, particularly in Barangays Masukol and Santa Cruz; projects in the upstream areas of Meycauayan and Balagtas; and conducted feasibility studies in rivers within Malolos and Meycauayan. DPWH Region 3 has revetment and bridge works in Masantol, Macabebe and Sasmuan. There are also projects in the Angat River, Pamawaran river, and Malolos river. DPWH has a bypass project in Lubao, Guagua, Minalin, and Santo Tomas. There is a proposal for the dredging in Hagonoy downstream of Pamawaran River under the inter-agency task force of DENR, DILG, DPWH, and DOTr. In the Pampanga River, there are proposed dredging projects. However, the proponents backed out. DPWH Region 3 is	[34]

Date	Activity	Objectives	Salient Points of Discussion	Ref.
			looking for other proponents. <u>Interphase with Other Agencies:</u> Some projects of DPWH Region 3 are in collaboration with DENR, DILG, and DOTr, particularly dredging projects in rivers. Projects of DPWH Region 3 are based on feasibility studies conducted by other agencies/entities. The DPWH Main Office approves funding for projects. DPWH Region 3 can assist RHDHV during the pilot period in terms of proposing a budget to their main office since DPWH's main office is the one who approves funding for projects. The budget ranges from Php 100 to 300 million if it is a regional project and below Php 100 million for continuing/by-pass projects.	
8 Nov 21	Meeting with San Miguel Corporation	Discuss the status of New Manila International Airport, including construction schedule, flood protection measures, social and environmental studies	SMC is currently developing a 15-km access channel to convey the dredging vessels that will supply the necessary resources for the platform. SMC will soon start with the formation of land for the airport, with an area of 1,700 hectares (the island footprint is 2,500 hectares). Physical construction will start in December 2021 for the filling of land. Once Phase 1 is completed by the 3rd Quarter of 2022, initial works for the airport will follow. Airport ground construction will also be conducted around that time. Target completion is early 2026. In April 2022, SMC will conduct river dredging to mitigate flooding in four Bulacan River Basin rivers, namely Taliptip, Pampanga, Sta. Maria, and Meycauayan Rivers. These rivers will be deepened and widened. SMC will conduct slope protection and biodiversity offsetting. Before 2021 ends, the mitigation strategies for social and environmental impact will be completed. Regarding land subsidence, SMC's consultant mentioned that the problem could be addressed through ground improvement.	[35]
10 Nov 21	Meeting with BFAR	Discuss ongoing and planned projects in the North Manila Bay area, interphase with other government agencies, data sharing	<u>Projects in North Manila Bay Area:</u> BFAR provides technical assistance to LGUs on the establishment of protected areas. The Philippine Ports Authority (PPA) requested for an expansion of the South Harbor, and BFAR gave their approval since the project area is relatively small; it met two of the criteria set by BFAR, namely: (1) preservation of marine biodiversity and fisheries; and (2) navigation channel. In the New Manila Airport project, BFAR was excluded from the discussion, hearings, and scoping maybe since the airport will be built on land and not part of the municipal waters.	[36]

Date	Activity	Objectives	Salient Points of Discussion	Ref.
			Out of 11 Fisheries Lease Agreements (FLAs), nine have already been cancelled, and the remaining two are in the process of cancellation. Interphase with Other Agencies: For activities beyond fisheries, permission from the LGU must be secured since they have complete jurisdiction over municipal waters. The DENR-Land Management Bureau designates abandoned areas to be alienable and disposable. After the cancellation of the FLAs, the following process is a reversion to DENR, which is the responsible agency for mangroves. With the cancellation of the FLAs by BFAR, LGUs have the misconception that they can claim these abandoned lands and have them titled. This was observed in some Bulacan LGUs that had lands covered by cancelled FLAs. BFAR has no documents proving they cancelled and transferred the land titles to the LGUs. Under the Wildlife Resources Conservation and Protection Act (RA 9147), jurisdiction over marine species (flora and fauna) is under BFAR except for dugongs and turtles, while land-based flora and fauna are within the scope of DENR. Mangrove areas converted to fishponds are also under the scope of DENR.	
12 Jan 2022	Meeting with NEDA Central Office and Region 3	Discuss findings, recommended nature-based solutions and pilot locations. Explore possible implementing and funding arrangements.	MBSDMP will be presented to the members of the Manila Bay Task Force within the first quarter of 2022 for further adaptations. Possible implementing agencies are DPWH and DENR. Coordination or agreement between these two agencies will be needed. DPWH is normally more interested in hard infrastructure instead of nature-based solutions. Meanwhile, DENR could be more interested in nature-based solutions. NEDA can advocate for this project and assist in convincing the agencies. Proof of effectiveness or benefits of nature-based solutions could be presented to the implementing agencies to have a more convincing proposal. LGUs are not the main implementor since the project goes beyond their jurisdictions. Nonetheless, LGUs should still be involved and could champion the project to the national agencies. It may be harder to convince municipal LGUs for this project. Provincial LGUs could be tapped together with the DPWH District Engineer Office. Richer LGUs could have access to funds from national government projects. Poorer LGUs have more difficulty in securing funding because of a lack of technical staff to deal with these kinds of projects. Provincial government could be tapped to assist smaller or poorer LGUs. NEDA can assist in the preparation of master plans. NEDA does not have allocated funds for master planning activities for 2022. For the MBSDMP, NEDA does not have to continue funding	[37]
14 Jan 2022	Meeting with DENR MBCO, Region 3, EMB,	Discuss findings, recommended nature-based solutions and pilot locations.	MBCO is more concerned with the portion of Manila Bay located in Metro Manila. Bulacan PENRO listed some of their ongoing projects as follows: (a) river cleanups conducted by hired rangers; (b) removal of silt mixed with garbage along Meycauayan River; and (c) water quality monitoring along the coastline from	[38]

Date	Activity	Objectives	Salient Points of Discussion	Ref.
	and Bulacan PENRO	Explore possible implementing and funding arrangements.	Obando to Hagonoy, in coordination with EMB Region 3. The dredged silt is deposited in small vacant lots near the river. LGUs do not utilize the dumped silt except to fill up the vacant lots. The lots are private property so permitting is not done. On the permits required in the proposed removal of dikes along the Pampanga River outfall to allow sediment accumulation, MGB and LGUs should be consulted. The sustainable development masterplans of the province or LGUs could also be consulted. On the environmental assessment aspect, EMB is concerned, but MGB is the main agency concerned. For the breakwaters where dredged sediments from the river are proposed to be reused, permits from MGB, DENR, and EMB are needed. An ECC is required if this is implemented in large scale.	
25 Jan 2022	Meeting with BFAR Region 3	Discuss findings, recommended nature-based solutions and pilot locations. Explore possible implementing and funding arrangements.	There is no updated inventory of fishponds to identify unutilized ones. The last inventory undertaken was in 2015. Another meeting can be arranged to discuss the process of reversing the Fishpond Lease Agreements (FLAs).	[41]
31 Jan 2022	Meeting with DENR MGB	Discuss findings, recommended nature-based solutions and pilot locations. Explore possible implementing and funding arrangements	In terms of coastal protection, MGB mentioned two current programs: (a) coastal vulnerability assessment and (b) offshore mineral resources of the Philippines. Around 470 municipalities are to be covered by the coastal vulnerability assessment by the end of 2023. MGB looks at shoreline shift, coastal bathymetry, and morphology in order to generate coastal vulnerability maps. In relation to the flood protection strategy, MGB has more expertise in the geological and physical aspects. The biological and ecological aspects must be interrelated since Nature-based solutions are an ecological-based approach. There are existing models to predict sediment patterns and geomorphic indicators in Manila Bay. Circulation patterns can predict the fate of sediments flushed from river outfall. Regarding dredging in North Manila Bay rivers, the dredging permit is issued by DPWH as the lead agency in collaboration with MGB. The EIA specifies the line of program that indicates where the dredged materials are dumped. MGB is not completely aware of the content of the EIA of these dredging projects since EMB is the agency that monitors the ECC. For dredging activities with commercial utilization of the dredged materials: • For areas less than 5 has., permit application is directed to the Provincial or City Mining Regulation Board. • For areas between 5 and 20 has., permit application is directed to the MGB Regional Director. • For areas greater than 20 has., approval of the DENR Secretary is needed If the dredged materials will not be commercially utilized. On the re-use of dredged sediments, dredging activities should have an incorporated EIA which specifies the fate of the dredged materials. This matter is mainly handled by EMB.	[42]

Date	Activity	Objectives	Salient Points of Discussion	Ref.
			On the removal of dikes along the Pampanga River outfall, DENR EMB normally requires an EIA. This will pass through MGB. In principle, any infrastructure project should include an Engineering Geology and Geohazard Assessment (EGGA), as required by DENR AO 2000-28.	
04 Feb 2022	Meeting with DPWH Central Office	Discuss findings, recommended nature-based solutions and pilot locations. Explore possible implementing and funding arrangements	DPWH has plans of implementing nature-based solutions, including putting a buffer for the rivers. But they need to pay for the right-of-way, especially from private owners. DPWH suggested that there should be a holistic model or simulation to show the effect of the solutions on flooding as a whole or locally. This will show the effectiveness of the proposed nature-based solutions and determine the priority level of each element. DPWH also stated that if there are some lacking elements in the plan, then it should also show its effect on the overall proposed nature-based solution system. The priority level/rank of each solution must be noted. Economic evaluation must be determined if this is already in the feasibility stage. DPWH also has ongoing projects in the Macabebe deltas. There are proposed river dredging zones with DENR for Angat river, Hagonoy river, etc. River widening proposed for NMIA can be considered for the project (Meycauayan river). RHDHV clarified that they already had previous discussions with SMC regarding the said rivers and confirmed that dredging is the main project in those areas. Dredged materials are recycled for dike construction. There are still other plans to consider for the proper disposal or recycling of dredged materials. Removal of dikes must be backed-up with data and results of studies to check if it will benefit the community in terms of flooding. This is because the community might suffer short-term problems while the removal is ongoing. If nature-based solutions are part of the master plan for this area, they will only implement within their respective mandates. Appropriate agencies must also be contacted independently for the solutions which are more applicable to their own mandates. Overall, DPWH suggested that the report must show the inland flooding results and the overall effects of the nature-based solutions. Comparison of the other alternatives must also be shown to denote the economic impact of each possible solution. Central and regional responsibility must also be highlighted to show the gravity of the project and how it will affect neighbouring mandates.	[43]

4.3.2 Webinar Session

A webinar was held on 7 and 9 December 2021 to orient stakeholders on a wide range of nature-based solutions that may be considered and whose applicability will depend on the physical features of the areas under consideration as well as the social acceptability by the residents.

The webinar included the following topics:

- Environmental context
- Types of nature-based solutions
- Root cause analysis
- Options for nature-based solutions to address root causes

Participants included 70 personnel of DPWH, NEDA, BFAR, DENR-MBCO, Malolos LGU, and ABB-BP.

Table 4-6: Webinar objectives and stakeholders engaged

Date	Activity	Objectives	Stakeholders Engaged
7 and 9 December 2021	Webinar on Nature-Based Solutions	Orient stakeholders on the root causes of flooding and the types of nature-based solutions to be considered depending on the physical features of areas under consideration and the social acceptability of residents.	DPWH, NEDA, BFAR, DENR-MBCO, Malolos LGU, ABB-BP

4.3.3 Community Consultations

Community consultations were held to introduce to stakeholders the project and nature-based solutions and get the perceptions of stakeholders on the following: nature of the flooding problem including depth, frequency, and root causes among others; national, local and community-based initiatives on flood protection; and nature-based solutions.

Community consultations were held in the following municipalities and city:

- Hagonoy, Bulacan
- Calumpit, Bulacan
- Paombong, Bulacan
- Malolos, Bulacan
- Masantol, Pampanga
- Macabebe, Pampanga
- Lubao, Pampanga

The project team members paid courtesy visits to the municipal/city officials and consulted with fishers, fishing vessel operators, and fishpond operators to gain insights on the following:

- Natural resources used in daily life
- Where floodwaters come from
- Warning signs of imminent flooding
- Hours between receiving warning and flooding
- Activities preparing for flooding threat
- Frequency of flooding

- Depth of floodwaters
- Causes of flooding
- Community/association initiatives
- Provincial/municipal government initiatives
- Expectations from nature-based solutions
- Advantages of nature-based solutions
- Disadvantages of nature-based solutions
- Concerns on implementation

The following are the main information gathered during the community consultations:

- Many have experienced a flood in their house. The source of floodwaters are:
  - Natural High Tide;
  - River water from upstream; and
  - Coastal flooding
- Fishery and aquaculture are the main forms of livelihood.
- Many households do not consider relocating from their home.
- Typhoon warning signals from the LGUs are very reliable for the communities.
- Communities are keen about the Nature-based Solutions approach. Many prefer mangrove green belts.
- Communities would like to retain the fish ponds to protect their livelihood.
- They are willing to setup an organization to help implement the flood protection strategy.
- For them, the advantages of nature-based flood protection in North Manila Bay are:
  - Opportunity to grow their livelihood;
  - Opportunity to have more aquatic species; and
  - Protection of the communities.

More details about the community consultations are presented in Appendix 3.

Table 4-7: Community Consultations Held

Date	Municipality Visited	Barangays Represented in Community Consultations	Objectives	Stakeholders Engaged
9 November 2021	Hagonoy	Tibaguin, Pugad, Sagrada, San Pablo, San Sebastian	To introduce to stakeholders the project and nature-based solutions and get stakeholders' perceptions on the following: nature of the flooding problem including depth, frequency, and root causes among others; national, local, and community-based initiatives on flood protection; and nature-based solutions.	Fishers, fishing vessel operators, fishpond operators
11 November 2021	Paombong	Several Barangays		
15 November 2021	Malolos	Several Barangays		
16 November 2021	Masantol	Several Barangays		
16 November 2021	Macabebe	Several Barangays		
11 November 2021	Calumpit	Several Barangays		
1 December 2021	Lubao	Bancal Pugad		

4.4 Stage 4: Feedback on the Strategy and Possible pilot

In this stage of stakeholder engagement, the findings of the Study were presented to the concerned stakeholders. The proposed nature-based solutions and possible pilot locations were discussed.

Another stakeholder consultation workshop was held in the morning of 21January 2022 to present the findings to fishers, fishpond and fishing vessel operators, and ABB-BP representatives from the municipalities of a possible pilot (Hagonoy, Macabebe, and Masantol). The root causes of flooding, proposed nature-based solutions, and recommended pilot locations were presented. During this consultation, the participants from the three municipalities concurred on the findings and the suggested nature-based solutions. They also agreed to become host of the potential pilot projects.

In the afternoon of 21 January 2022, another consultation was held, this time with LGU and ABB-BP officials and representatives from Hagonoy, Macabebe, and Masantol to present the findings, suggested nature-based solutions, and institutional arrangements. The consultation also explored possible sources of funding for the proposed pilot project.

The last stakeholder workshop was held on 16 February 2022 to present the Flood Protection Strategy to the engaged stakeholders from government agencies and other institutions.

Table 4-8. Consultation workshops held in Stage 4

Date	Activity	Salient Points of Discussion
21 Jan 2022 (morning)	Stakeholder Consultation Workshop (face to face) with Fishermen and Fishpond Operators of Hagonoy, Masantol, and Macabebe	All attendees agreed with the findings of the Flood Protection Strategy study regarding the root causes of flooding and the condition of the areas along the bay. It was added that the river in Hagonoy has become narrower due to the construction of structures. The river is also shallow and has not been dredged in years. All attendees agreed with the proposed locations for the pilot flood protection project. The practicality of some of the proposed solutions, such as the inland earth dike in Hagonoy, was discussed. A way forward is to incorporate the proposed solutions to the CLUP. Implementation of the CLUP is vital. River deepening instead of river widening was recommended by some attendees since Pampanga River is already wide (approximately 3 km). Attendees from Macabebe and Masantol agreed that sediments in Manila Bay shore brought by Pampanga River can potentially be re-used for filling the proposed embankments. Some fishpond operators in Macabebe have already adopted green embankments. They planted nipa palm along the existing embankments which became a source of producing nipa vinegar, thus providing them with additional livelihood. Most fishponds along the coast of Hagonoy are not operational. Interest in hanging structures and shellfish reefs was expressed because of the opportunity to increase livelihood.
21 Jan 2022 (afternoon)	Meeting with ABB-BP/LGU representatives from Hagonoy, Masantol, and Macabebe	Regarding the implementation of the proposed flood protection strategy, four main issues were identified: funding, institutional capacity, sustainability, and coordination with other LGUs. Masantol has an approved Comprehensive Land Use Plan (CLUP) for 2017- 2026, including zoning ordinance and comprehensive development plan. Macabebe has a CLUP but still pending for updating. Hagonoy has yet to define its Coastal Management Plan. Each municipality of ABB-BP has a technical working group composed of different entities such as the municipal engineer or the municipal disaster mitigation officer. It was proposed to present the flood protection strategy to the LGU principal authorities (Mayor + Council) through the technical working group. If the principal authorities of the LGU approve the project, it could be implemented.

Date	Activity	Salient Points of Discussion
		The elections in May 2022 and the changing of the administration, especially for the succeeding mayors, is a major consideration in tapping the LGUs. The Department of Budget and Management (DBM) can provide funding or budget through the program “Assistance to the disadvantaged municipalities and cities.” LGUs will need the endorsement of the Department of Interior and Local Government (DILG). More than 50% of the fishponds in Macabebe are non-operational due to the occurrences of storm surge and tidal flooding. Some of these were converted to fish pens since the dike have collapsed. Most inter-municipal cooperation efforts are mostly informal. Thus, ABB-BP has no model to guide them in their legal incorporation.
16 Feb 2022	Presentation of Flood Protection Strategy (online)	The findings of the Study was presented. The presentation aims to increase the appreciation of nature-based solutions as flood protection strategies for North Manila Bay and relay the importance of establishing pilot locations in a flood protection plan. Representatives of NEDA attended the presentation, DPWH, DENR Region 3, MBCO, EMB, BFAR, ABB-BP, Guiguinto CENRO, Bulacan PENRO, Pampanga PENRO, Wetlands International, Shell, Studio Flow Consultancy, Netherlands Embassy, RVO and RHDHV.

4.5 Stage 5: Stakeholder Analysis

A power–interest matrix was used to classify stakeholders in terms of the power they hold and the extent to which they are likely to be involved. The level of control of each stakeholder is reflected on the vertical axis, and their level of interest is measured on the horizontal axis. Figure 4-1 shows the level of control and welfare of the identified key stakeholders in the North Manila Bay area and the proposed extent of engaging and communicating with them.

Quadrant A. "Low Power, Low Interest (Bystander)."

Found in Quadrant A are stakeholders who have low stakes and low interest, just watching from the sidelines, hence the term "bystanders." They may monitor the project’s progress and wait for the results. Still, beyond that, they do not have heavily invested stakes within the sector and usually have little influence on government policy. These stakeholders require minimal effort (e.g., monitoring) and may be generally informed and involved in low-risk matters.

Quadrant B. "Low Power, High Interest (Advocate)."

NGOs, barangay officials, fishermen, fishpond operators, fishing vessel operators and other residents comprise Quadrant B stakeholders. NGOs refer to local and international NGOs which work with local communities on environmental issues, coastal zone management, livelihood development, resilience, and disaster preparedness. The NGOs are sources of local knowledge and are partners of the local communities on advocacy, project planning, and implementation. They have a high level of interest but have relatively scarce resources and little influence in terms of policy-making.

Barangay officials have a high level of interest as the Project would potentially affect their constituents' livelihood and income levels. Their interest will be to implement nature-based solutions that would enhance disaster risk reduction and uplift the fishermen's' and other coastal residents' well-being.

The fisherfolks and other residents are very much interested in the Project, hopeful of the benefits that nature-based solutions may bring, such as increased fish catch, increased income, reduced disruption in their daily activities, reduced damage to properties, and more time to spend on productive endeavors that generally would have been spent on preparing/reinforcing houses before flooding and cleaning homes after flooding.
NGOs, barangay officials, fisherfolks, and other coastal residents have high stakes but relatively little power. They can thus be important allies and advocates in influencing the more powerful stakeholders. These Quadrant B stakeholders should be kept updated with the findings and progress of the Project and their interest maintained.

Quadrant C. "High Power, Low Interest (Possible Mover)."

Stakeholders in Quadrant C are influential, but their interest in the project is relatively low. They are generally passive, but certain events can stimulate their interest and move them to Quadrant D, especially if their intiatives will be significantly affected by nature-based solutions. These stakeholders should generally be kept informed and likewise monitored as their initiatives can potentially contribute to the flooding problem in the North Manila Bay area.

Quadrant D. "High Power, High Interest (Key Player)."

The stakeholders in Quadrant D are the key players who should be engaged closely and with whom the Project's working relationship should be kept strong. These include ABB-BP, DPWH, NEDA, DENR-MBCO, DENR-EMB, and BFAR. They are both powerful and highly interested in nature-based flood protection strategies. These are entities involved in policy, project identification, development and approval, funding, implementation, operation, and supervision. Government support is critical.

The LGU members of ABB-BP (City of Malolos and towns of Calumpit, Hagonoy, Paombong, Bulacan, and Obando in Bulacan province and towns of Masantol, Macabebe, Lubao, and Sasmuan in Pampanga) represented by their respective mayors have the power to become project implementors and/or co-founders of the Project. Because of the forthcoming May 2022 national and local elections, the Project Team must be viewed as politically neutral. The local chief executives engaged in the Project may not be the same local top executives in July 2022 during project implementation.

San Miguel Corporation is likewise found in Quadrant D since its airport city project is located in Bulakan municipality, an LGU member of the ABB-BP. If Bulakan municipality gets selected as a pilot location for the Project, San Miguel Corporation likewise has the power and the potential to co-opt with the Project.

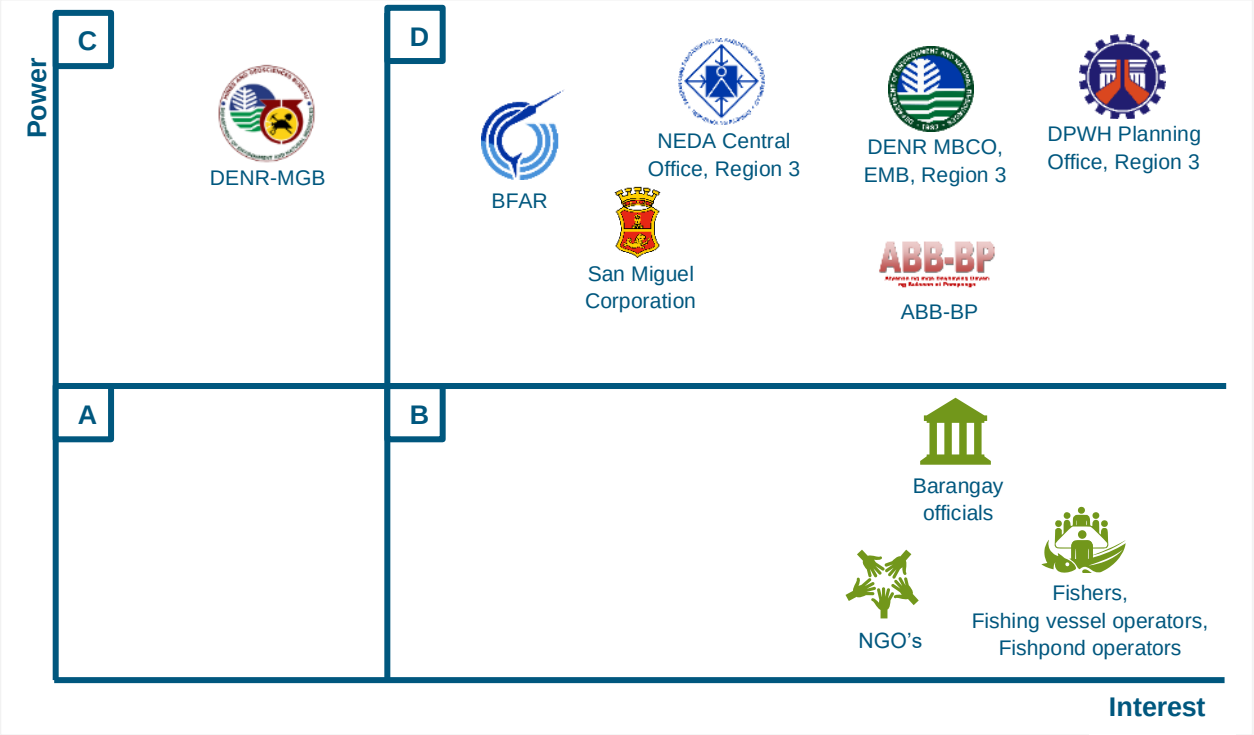


Figure 4-1: Power-Interest Matrix

5 Site visits and household surveys

For the team that is executing this North Manila Bay Flood Protection Strategy, understanding the North Manila Bay Delta area is pivotal in making a strategy that considers the local interest. Furthermore, the first projects arising from this strategy are expected to be smaller thus, locally implemented projects will require support from the local inhabitants and government units. Site visits and ocular inspections were conducted at the same time the community consultations and household surveys were held.

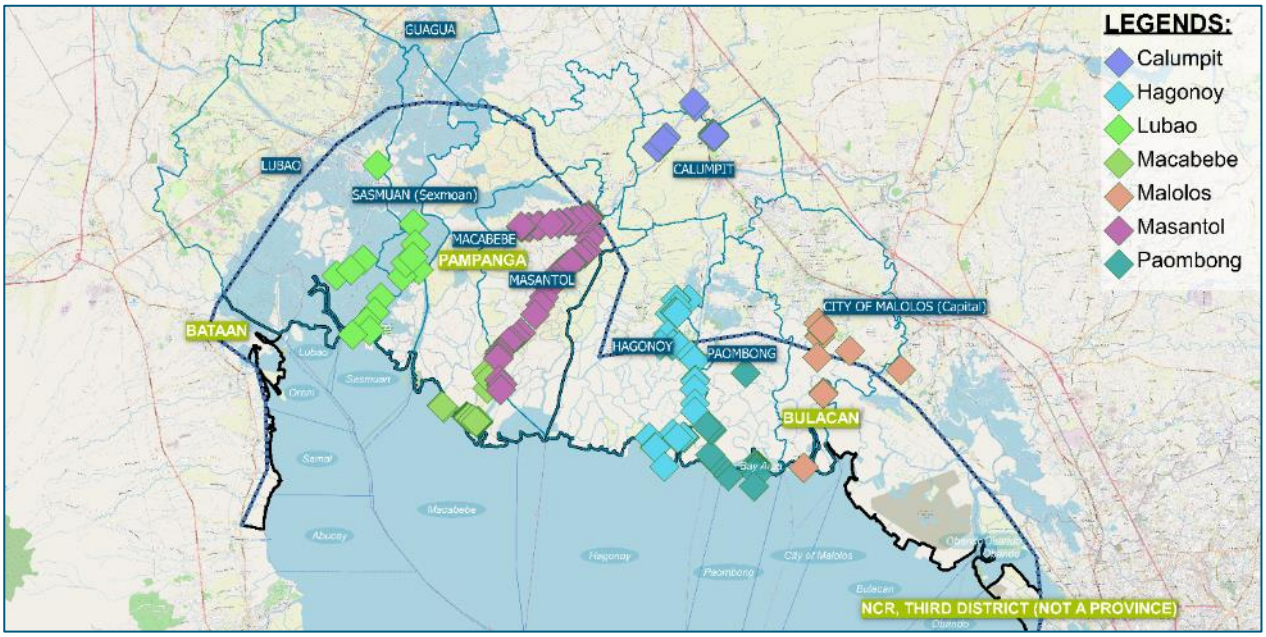


Figure 5-1: Locations of site visits

The site visits are a combination of the following activities:

- Courtesy visits with Mayor and Vice Mayors of concerned LGU(s)
- Meetings with other representatives of LGU and (regional/local) governmental organisations
- Community consultations
- Household surveys
- Photo canvassing
- Drone surveys

During the site visits an abundance of data, surveys, photos and videos were gathered. Refer to Appendix 3 for more details. More interactive data can be viewed digitally in the iReport of this strategy [LINK].

Household surveys were conducted among the barangay residents in Bulacan and Pampanga on the same days the consultations were held. The survey was undertaken to generate community-based data in addition to the information generated during the community consultations.

The household survey asked the following questions:

- Location
- How old are you?
- What is the strongest Typhoon you experienced?
- How deep was the flooding during typhoons and high tide?
- What is the impact of this flooding on your livelihood?

- What damages do you experience during this typhoon?
- How much is the damage in your house during flooding?
- What is the coastal hazard you experience the most?
- What have you done to reduce the risk of disasters?
- What do you do to prepare when you know flooding is going to take place?
- Does the barangay have an early warning system?
- What is the lead time of this warning?
- What is the primary form of livelihood in your household?
- What is your main source of water?
- In times of disaster, do you have access to transportation?
- In times of disaster, do you have access to a safe shelter?
- Is the drainage system in this community sufficient to deal with heavy amounts of rainfall?
- Have you noticed any changes in the environment and available resources in the last 5 years?
- Do you know of any government plans to mitigate the coastal hazards?
- Are you willing to move to relocation sites?
- How do you use the natural environment in your daily life
- How do you feel about a mangrove forest in front of the current coastline? What are your worries
- What do you expect from a nature-based solution/what do you need/what do you want it to bring to you?

Table 5-1 shows the municipalities and stakeholders approached in the household surveys, and Figure 5-2 shows the locations of these surveys. A total of 62 household surveys have been conducted. Appendix 3 shows an analysis of the survey data.

Table 5-1: Household Surveys Conducted

Date	Municipality	Barangays Covered	Stakeholders Engaged
9 November 2021	Hagonoy	Tibaguin, Sagrada, San Pablo	Baragay residents
11 November 2021	Paombong	Sta. Cruz, Poblacion	Barangay residents
15 November 2021	Malolos	Pamawaran	Barangay residents
16 November 2021	Masantol	Sapang Kawayan, Palimpe	Barangay residents
16 November 2021	Macabebe	Poblacion	Barangay residents
17 November 2021	Calumpit	Meysulao, San Miguel, Sapang Bayan	Barangay residents
1 December 2021	Lubao	Bancal Pugad	Barangay residents

Based on the conducted surveys, the following conclusions can be drawn. It has to be noted that the survey is based on interviewing a limited amount of people and might not be representative outside of the context of their location.

The ages of the people interviewed range from 22 to 74. About half of the interviewees are within the age bracket 40-60. The strongest typhoon experienced by one-third of the interviewed residents is Typhoon Ondoy (2009), while one-fifth of the interviewees noted Typhoon Yolanda/Haiyan (2013) as the strongest. Perceived flood depths range from knee level to more than 1.5 meters. Half of the residents experienced a flood incident that reached a depth of at least waist level.

The most common coastal hazard experienced in the surveyed areas is flooding during high tide. The most recurrent impact of flooding on livelihood is loss of income due to the unavailability of work opportunities during and after flooding. This drives the affected residents to rely on donations from government agencies and non-government organizations. The most frequently damaged in the households are roofs and furniture. In order to reduce the risk of disasters, most residents adapt their houses, for instance, building houses on

stilts and constructing the ground floor at high elevations. To prepare for impending floods, the most common practice is to store food, water and medicine. Some families also evacuate to designated shelters. Most of the barangays have an early warning system which provides additional protection for the residents. The lead time of this warning varies from a few hours to more than one day. About 68% of the households are aware of any government plans to mitigate the coastal hazards.

Fishery is the most dominant livelihood in the areas. Seventy percent of the surveyed households rely on fishing and/or selling fishes in the market as primary form of livelihood. The main source of water for 73% of the households is the water distribution pipes. The rest collects water from wells, tanks, and water trucks. About half of the households use the natural environment as source of food and livelihood such as aquaculture and fishery. Perceptions of changes in the environment and available resources in the last 5 years are mixed: some believe the situation improved while others think otherwise. About 66% believes that the drainage system in their community is not sufficient to deal with high rainfall volumes. In times of disaster, 89% have access to transportation and 95% have access to a safe shelter. Most residents, about 73% of the surveyed, are not willing to move to relocation sites.

The most common perceived benefits of nature-based solutions are safety against flooding and improved fishing grounds for their livelihood. Some also expect a greener environment and higher biodiversity as benefits. About 62% of the survey do not perceive any disadvantages or worries about a mangrove forest in front of the current coastline. Others worry about livelihood interference and maintenance.

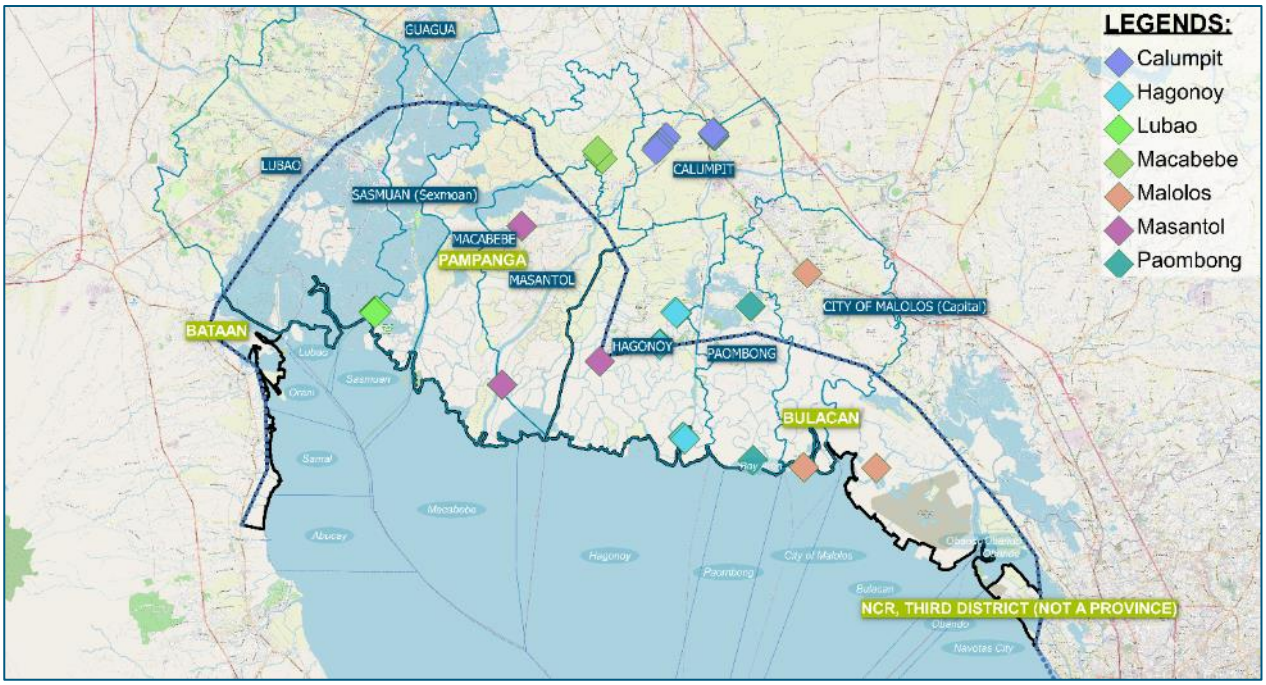


Figure 5-2: Locations of surveyed households

6 Institutional Setting

Analysing and finding the right institutional setting will be pivotal for the success of smaller-scale implementation and the implementation of the strategy itself. This chapter will show that with the Integrated Coastal Management policies and the Manila Bay Sustainable Development Masterplan in place, the regulatory framework that is needed to implement this strategy exists. Nevertheless, this strategy also acknowledges and finds mitigations for situations in which the Integrated Coastal Management implementation staggers or its ambitions are not translated to physical projects. Moreover, it is taken into account that the Manila Bay Sustainable Development Masterplan will (not yet) be ratified. This Section firstly gives an overview of the several institutions involved, after which the institutional risks are discussed. Section 6.4 and 6.4 discuss the existing local and regional structures. After which, a long-term and short-term institutional setting is proposed.

6.1 Institutions

An overview of the institutional responsibilities of the National Government Agencies and LGUs in the Philippines is provided in Table 6-1. It is emphasized that while many agencies have roles to play in developing flood protection measures, all must have prior approval from the municipality and the stakeholders. This is also one of the foundations of the Integrated Coastal Management policies set up by the Philippine Government (see Chapter 6.4)

Table 6-1 - Jurisdiction and Mandate

Agency	Mandate	Activities	Boundaries
Municipal LGU	• Jurisdiction over all land within the LGU land and sea boundary three km from the coast (municipal waters); • Responsible for infrastructures for public services funded out of municipal funds, including flood control structures. • Execution of ICM policies and projects.	• Constructions and building activities are covered by ordinances. • Prepare Comprehensive Land Use Plan [45] with its accompanying documents [46] • Manages operations of fishponds in private and private lands through business permits • Maintenance of mangrove plantings	• All ordinances, including CLUP, funding of projects, shall be approved by the provincial legislature. • No funding from ICM pushing through
Provinces	• Responsible for infrastructures for public services funded out of provincial funds, including flood control structures.	• Constructions and building activities as per provincial ordinances or using resources of national agencies; • Reforestation efforts including mangroves; • Prepare Provincial Development & Physical Framework Plan [47], which guides the preparation of CLUPs	• By national laws and in coordination with national agencies with the primary role to implement these laws, particularly DPWH and DENR; • Local authorities must also approve activities in the municipality.
Housing and Land use Regulation board [48]	• Promulgates zoning and land use standards and guidelines governing land use plans and zoning ordinances of LGUs. • Involvement in relocation efforts in the ICM framework.	• Reviews final drafts of CLUP and PDPFP as to their conformity with national laws. Mandatory review of CLUP affected by natural hazards to determine if climate change and disaster risks are mainstreamed in the documents and assist in these risk-sensitive CLUPs. [49]	• Must approve provisions of CLUP and PDPFP

Agency	Mandate	Activities	Boundaries
District Congressman	• Advocate for projects in the district to be funded by the national budget.	Flood mitigation measures in LGUs implemented by DENR and DPWH.	Budget proposals to the Congress shall require meetings with stakeholders
Regional development council	Align local plans with national programs	Assists LGUs in preparing development plans ensuring compliance with national programs, and facilitating funding from national agencies.	Align projects of LGU officials and national agencies' activities with the region's overall program.
Department of Environmental and Natural resources	Exercises exclusive jurisdiction on the management and disposition of all lands in the public domain. [50]	• Implement projects as programmed in national budget or upon request by the provincial or municipal LGUs using these LGUs' funds; • Mangrove plantings in foreshore areas; • Recommend to the presidential declaration of specific areas as Environmental Critical Areas or marine reserves • Management of Protected Areas	All projects must get approval from municipal LGU, which requires consultation with stakeholders.
Bureau of Fisheries & Aquatic Resources	Issues or cancels Fishpond Lease Agreement [51] for public lands	Monitors compliance by lessees of FLAs	Municipal LGU legislature must approve the FLA in a resolution or ordinance. This requires a public hearing of the stakeholders.
National Water Resources Board	Manages and approves all uses of water resources in the country, including surface and sub-surface water	A total ban on deep wells in Guiguinto, Bocaue, Marilao, and Meycauyan since 2015	Prior approval before LGU allows deep wells or use of surface water or residential and commercial uses.
Local water utility administration	Pursue the government's goal of universal access to safe water and sanitation in the countryside by developing local water districts and partnering with other institutions.	Assist local water districts in expanding piped-in water to discourage the use of deep well water, thus reducing ground subsidence.	Close coordination with municipal waterworks.

Agency	Mandate	Activities	Boundaries
Department of Public Works and highways	• construction and developments along with foreshore areas [52]; • hard structures	River dikes, levees, river dredging, ring dikes	• Municipal LGU legislature must approve the project in a resolution or ordinance. This requires consultation with stakeholders in a public hearing; • If the project is more than PHP 500 M, the Regional Development Council must approve it. • The DENR must issue an Environment Compliance Certificate (ECC)
Philippine Port Authority	Issuance of permit on the construction of piers, ports [53]	N.A.	• Municipal and provincial LGU legislatures must approve the project in a resolution or ordinance. This requires public hearing of the stakeholders;
Bureau of Fisheries & Aquatic Resources	Issues or cancels Fishpond Lease Agreement [51]	Fishponds with expired permits or violations may already be reclaimed by the DENR either to be leased out to new operators or used as catch basin or mangrove plantings;	Municipal LGU legislature must approve the FLA in a resolution or ordinance. This requires a public hearing of the stakeholders.
Philippine Reclamation Authority	Responsible for activities about reclamation [54]	. Approves foreshore reclamation projects	• Municipal and provincial LGUs legislature must approve the project in a resolution or ordinance. This requires a public hearing of the stakeholders. • DENR issues ECC
National Disaster Risk Reduction Management Council [55]	Formulates policies and programs to protect communities against natural disasters, including flooding	• Recommend to LGUs measures activities to lessen effects of natural disasters; • Recommend “no-build zones” ; • Guide LGUs in preparing Local Climate Change Action Plans	Formulation of recommendations done in coordination with relevant national agencies and stakeholders.
Department of Tourism	Responsible for the development of an area as a tourism zone and marine reserves [56]	Tourism as a livelihood activity in conjunction with appropriate Nature based Solutions.	Municipal LGU legislature must approve the designation in a resolution or ordinance. This requires a public hearing of the stakeholders.
Pampanga River Basin Committee	Regional Body primarily in charge of the Implementation of the Integrated Water Resources Management (IWRM)	Premier regional coordinating body exercises advisory, guidance, education, and monitoring functions for the Basin’s management and development. [54]	No apparent conflicts in LGUs
Manila Bay Task Force	Expediting the Rehabilitation and Restoration of the Coastal and Marine Ecosystem of the Manila Bay	Mobilizes the participation of both Mandamus and non-Mandamus agencies through human resources, funding, and logistics contributions	

The agencies outlined in Table 6-1 act on different levels over government; however, the following agencies are deemed crucial because of their abilities:

- LGU – the Local Government Unit:
  - Is the final approver for implementing the projects.
  - Needs to identify the Integrated Coastal Management policies (ICM) from NEDA and DENR.
  - Needs to establish the Comprehensive Land Use Plan (CLUP) based on ICM
  - Best suited to encourage the communities the use of Nature-based Solutions.
  - Should budget to maintain the implemented flood protection measures.
  - Best connection to the fishpond owners
  - LGU plays a big role in implementing any flood protection strategy.
  - Inform the community and play a pivotal role in motivating innovative/alternative ways livelihood.
- DENR:
  - Implementation of the Integrated Coastal Management policies, see Chapter 6.4.
  - Approving ECC/EIA studies for dredging, reclamation and other land conversion projects.
  - Recommending the declaration of ECA and marine reserves in the foreshore and municipal waters to encourage mangrove growth.
  - Executing the guidelines and monitoring as part of the implementation of the Clean Water Act (RA 9275) on the use of chemical feeds for aquaculture to present runoffs from poisoning mangroves.
  - Implementation of the Ecological Solid Waste Management Act (RA 9003) which encourages mangrove growth and cultivation.
  - Encouraging recoveries of unused fishpond leases (in coordination with BFAR) in public lands to use for Nature-based Solutions (i.e., mangrove plantings, embankments, and production areas for fisherfolks).
- DPWH
  - DPWH funds bigger flood protection schemes.
  - DPWH has the role of approving the plans and financial resources within the Mandamus area.
  - On-going dredging activities in Macabebe Deltas. There are proposed river dedging zones in collaboration with DENR for Angat River, Hagonoy River, etc.
  - On-going river widening in Meycauayan River proposed by NMIA.
  - On-going project for road elevation in Macabebe and Masantol to prevent flooding in the municipalities.
- BFAR:
  - Identifying the operational fishponds in North Manila Bay.
  - Identifying the fishponds that have a lease title. BFAR does not have the authority to mandate the existing private fishponds.
  - Coordinating with LGU to evaluate the public and private fishponds and determine their respective responsibilities.

6.2 Institutional Risks

The outputs of the Focus Group Discussions among the stakeholders and the Manila Bay Sustainable Development Masterplan [57] include the comments and sentiments of the communities and stakeholders concerning the flooding situation in their respective areas. It appears that the communities, overall, have resigned to co-exist with the occasional and periodic flooding. They feel, however, that the flooding incidents have become more pronounced and are affecting more areas compared to 20 years ago. Currently, the overriding interests of the communities are:

- Bringing back the cleanliness of the rivers and waters to regain their productivity;
- Rescue and relief procedures during occasions of deep flooding; and
- Building more concrete dikes to reduce flooding in affected areas.

The concerns and issues of the stakeholders were used to determine the weaknesses and inadequacies in the current governance structure and systems in the context of flood mitigation. In addition to the Focus Group Discussions, reference reports such as the Manila Bay Sustainable Development Masterplan, Climate Responsive Integrated Master Plan for the Pampanga River Basin [54] and discussions by academics and experts in social media were used in the analysis:

Table 6-2 - Perceived Weaknesses of Governance Institution

Evidence	Disclosed Institutional Situation and Bias (DISB)	Possible Responses to DISB
Ring dikes surrounding communities facing the sea half-done or destroyed in part.	• The municipalities are biased towards employing complex structures as flood mitigation measures. NBS, not a popular option. • The LGUs have limited funds for rigid structures of flood mitigation measures. Due to a lack of resources, many are left uncompleted, rendering them ineffective. • Dependence on the national budget and national agencies (mainly DPWH) for the LGUs' flood mitigation measures. The scheduling of construction – and meeting their objectives – cannot be predicted.	• Higher Internal Revenue Allotment by LGUs (23% increase) beginning 2022 can be used to fund flood mitigation measures; • Add NBS as part of the "tools" of LGUs as these are cheaper and more sustainable; • Closer work with congressional district representatives to obtain funding for complex strategic structure and accompanying NBS.
Floods are more profound compared to 20 years ago.		
Reliance on river dikes, levees, and river dredging as flood mitigation measures.		
Destruction of community mangroves due to sea level rise and transformation into fishponds and allowing these to remain in disrepair; mangrove areas becoming smaller	• Weak monitoring by environmental and engineering offices; • Inadequate attention and investments on the protection of community mangrove and support for community mangrove replanting efforts	More investments from municipal and provincial LGUs for: • Breakwaters to also protect the mangroves from destructive typhoons; • support for barangay volunteers and NGOs year-round replanting efforts in former mangrove areas; • expropriation or purchase of marginal fishponds to restore mangrove areas; • prior and free consent relocation of ISF from mangrove areas.

Evidence	Disclosed Institutional Situation and Bias (DISB)	Possible Responses to DISB
ISF in danger areas along the riverbank and environmentally critical areas	• Lack of personnel and equipment in key offices result in weak enforcement of zoning ordinances and environmental laws. • Lack of "political will" among municipal and village administrators might effectively implement ordinances and laws or pass regulations that serve the majority rather than the elite.	• Capacity-building and professionalization of appropriate office to consistently enforce the laws and regulations. • Creation of private sector groups assisting formal offices (i.e., "force multiplier") in monitoring environmental and fishery laws, including monitoring the effectiveness of flood mitigation measures.
Pollution of riverways from chemical feeds in fishponds		
Use of illegal fishing methods by some fisherfolks		
• Many fishing communities have no established fisherfolks associations; • Many communities have no cooperatives or private sector associations (i.e., women, food processors, vendors, etc.)	• Input of private sector stakeholders not material to the conceptualization of policies and activities; • The community members most affected by flooding may not be able to participate in the NBS	Organize the private sector stakeholders into associations and cooperatives as part of NBS activities to participate and benefit from the ancillary livelihood projects.
People most affected by flooding appear resigned to their fate; they require timely rescue and relief goods.	Frequent dislocations and disruptions created by flooding lessen average incomes and lower quality of life.	• Creation of alternative livelihood accompanying and arising from NBS • Adaption capacity-building and support
Floods are more profound because of land subsidence. This also has the effect of preventing the planting of more mangroves along the littoral zone.	Under service by water districts, reliance on a deep well. While deep wells are already prohibited, some communities persist in the practice for lack of alternative	Expand water district services; establish "no-build zones" in areas of ground subsidence.

More effective intergovernmental relationships are required to make decentralised approaches for coastal management work. This includes capacity support (e.g., availability of experts, knowledge transfer, and training) from DENR, DPWH, and DILG to the LGUs to include ICZM/DRRM/CCA principles and the integrated thinking into their CLUPs and projects, as well as proposals to the Regional Development Council. As use of NbS is new in the Philippines, there is a lack of knowledge and practical implementation experience and best practice external technical knowledge transfer (capacity-building) will often be needed. Ultimately, it also requires the political will of LGUs to facilitate the coordination between all the different stakeholders involved.

6.3 Existing local institutional structures

The governance system in the LGUs has a substantial impact on flood management efforts. The local context is evidenced and implemented through the documents and offices set forth below. Summarized are the comments and observations regarding these governance components.

Table 6-3 - Governance instrument and structures that impact flood management measures

Institutional Structure & Governance System	Observations and Weaknesses	Proposed Responses
Comprehensive Land Use Plans of Provinces and Municipalities – main guidelines of the LGUs for planning and use of land (and water) areas	There is a need to review the CLUPs – and their accompanying documents (Zoning Plans, Investment Plans) if these promote the measures that mitigate flooding.	Amending the CLUP is a long-drawn-out process (i.e., 2-8 years) and is not practical for the purposes of this Project. It is best to work on the parameters set by ordinances. The proponents would just "cherry pick" areas set out in the CLUP that best serve this project's measures.

Institutional Structure & Governance System	Observations and Weaknesses	Proposed Responses
Zoning Plans - delineates and manages the uses of land features	General weakness in the enforcement of zoning plans. This led to ISF's existence and unsustainable land and water resources.	It is vital to develop the key offices' human resources whose mandates impact flooding mitigation and its effects.. There is also a need to create a corps of trained regulators insulated from political and personal pressures to implement the laws and regulations.
Investment Plan – another companion document of the CLUP. This sets out the vision and mission statements set out in the CLUP into activities with financing estimates and funding sources.	Complex structures as flood mitigation measures are generally "big-ticket" items and rely on the national government for funding	
LGU Offices -responsible for implementing rules and regulations	At the municipal level, they are generally lack in personnel, resources, and training. At the village or barangay level, the regulators are volunteers. While committed, these lack training, resources, and material support.	
Environmentally Critical Areas [58]– areas declared by DENR after procedure required by law to be of such character, nature, and use to merit special protection from the government. Once proclaimed said as ECA, the jurisdiction of LGUs over these areas would be correspondingly limited.	There is no ECA along the riverbanks and entire North Manila Bay coastal area. Jurisdiction by the LGUs over the ECA is limited and subject to regulations set by DENR. The ECAs merit special protection and material support. The lack of ECA declarations makes it harder for national agencies to protect environmentally critical areas or implement activities in them.	Key portions of the coastline and floodplains of international importance as defined by conventions and multi-lateral partnership agreements should be declared ECA. This will allow stricter enforcement of environmental laws, allow management and better protection of ECAs and funnel in more resources from the national coffers to protect and enhance the area's ecology. These ECAs selected must have features that will assist in the reduction of flooding and its accompanying risks.

6.4 Existing regional & national institutional structures

6.4.1 Manila Bay Task Force

The Manila Bay Task Force was created based on Administrative Order No. 16 [59] to fast-track the rehabilitation and restoration of the coastal and marine ecosystem of Manila Bay. The task force is headed by DENR and supplemented by various agencies. Administrative Order No. 16 has the following goals that closely relate to the North Manila Bay Flood Protection Strategy:

"Undertake remedial measures using engineering and technological interventions to improve the water quality of the Manila Bay, such as sustained and targeted reduction in the coliform level in all major river systems and tributaries within the Manila Bay Region [59]"

"Ensure that the concerned agencies and LGUs undertake appropriate measures relative to violation of environmental laws such as, but not limited to, demolition, closure or cessation of business and/or filing of administrative action against erring persons or establishment [59]"

During the preparation of the North Manila Bay Flood Protection Strategy several discussions with the Manila Bay Coordinating Office (MBCO) have been held as part of the meeting structure with DENR. Concrete actions or ideas from utilizing the Manila Bay Task Force have not been solidified during these meetings. This strategy aligns with the Manila Bay Sustainable Development Masterplan and does not see the Manila Bay Task Force as an implementing agency for flood protection/Nature-based Solutions projects.

6.4.2 Integrated Coastal Management

Under the Local Government Code and also the Integrated Coastal Management Act (EO533) [60], the Philippines have decentralised the Integrated Coastal Management (ICM) to the LGUs under the guidance of DENR:

"LGUs shall update their respective ICM programmes to reflect changing social, economic and environmental conditions and emerging issues. LGUs shall furnish the DENR, within one month from adoption, with copies of their ICM programmes and all its subsequent amendments, modifications and revisions. LGUs shall mobilize and allocate necessary personnel, resources and logistics to effectively implement their respective ICM programmes. [60]"

EO533 makes the LGUs the "champion" of implementing ICM through zoning and requesting funds for projects. During site visits and stakeholder meetings, it became clear that most LGUs struggle with this task due to a lack of resources.

Amongst others, the ICM responsibilities from the LGUs should result in:

"Coastal strategies and action plans that provide a long term vision and strategy for sustainable development of the coastal area, and a fixed-term programme of actions for addressing priority issues and concerns [60]."

and

"Investment opportunities and sustainable financing mechanisms for environmental protection and improvement and resource conservation [60]."

The LGUs are supposed to have extensive power for specified functions, including assessment, planning, regulation, legislation, enforcement, revenue generation, and monitoring of their marine and coastal resources within their municipal water boundary. Nevertheless, decentralised approaches to managing coastal resources are more than just a general transfer of responsibilities. It is the combination of understanding ecosystem services and benefits, building trust, strengthening local government capacity, handling multiple users, interests and stakeholders, and enhancing the governance system's upward and downward accountability mechanisms among local government.

The North Manila Bay Flood Protection Strategy can act as a basis for the LGUs to request funding for projects from the DENR and DPWH, among other for the budget round of 2023. To make this possible, the LGUs should be supported by DENR and other national agencies and capable technical NGOs in capacity building and adequate resources to look, request, implement and monitor projects.

6.4.3 Manila Bay Sustainable Development Master Plan

The Nature-based Solutions as planned in this strategy are part of the Manila Bay Sustainable Development Masterplan efforts to reduce exposure to flooding. As part of the Masterplan the current institutional setting has been analysed, and it was concluded that the current mechanisms, under which the Integrated Coastal Management and the Manila Bay task force:

"Do not have the stability and sustainability required, including the agility needed to respond to immediate and urgent challenges and issues. It does not have the direct political strength to ensure compliance and coordination of efforts but will have to go through the long processes and leadership in DENR [57] "

The Manila Bay Sustainable Development Masterplan aims to setup a the Manila Bay Development Commission which must be able to meet the critical institutional requirements of Manila Bay as set out in the Manila Bay Sustainable Development Masterplan, including relevant national and global targets and programs on sustainable development and climate change

"The Manila Bay Development Commission is the primary agency mandated to ensure integration of all plans, policies and programs of agencies and local government units involved in the development of Manila Bay and the Manila Bay Area and its inhabitants, and to align these with the Manila Bay Sustainable Development Master Plan. It is responsible for the effective and efficient coordination of all stakeholders in the implementation of plans, policies, programs, and activities, and in the provision of relevant, up-to-date, evidence-based, accessible data and information about Manila Bay and the Manila Bay Area. It has oversight power in plan and program development and in policy formulation, as well as in the monitoring and evaluation of these. [57]"

It has to be noted that regarding funding, the Manila Bay Development Commission will assist agencies, LGUs and private sector in selecting appropriate funding schemes and funding sources. The commission will not be able to fund projects/schemes by itself.

The proposed organisational structure of the commission is shown in Figure 6-1

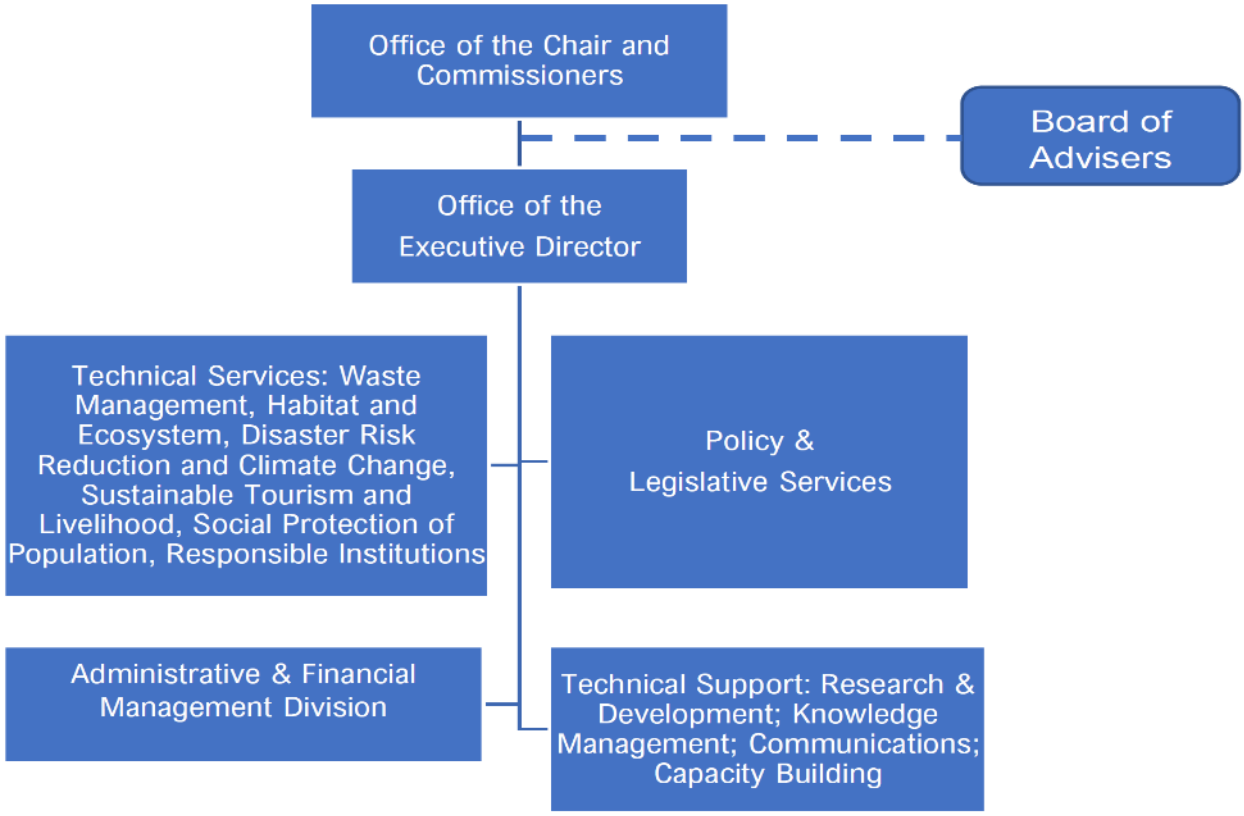


Figure 6-1: Manila Bay Sustainable Development Masterplan proposed Manila Bay Development Commission structure [57]"

As for the other two regional & national institutional structures, current legal arrangements among the LGUs and the national agencies are not affected by their implementation. The proposed Manila Bay Development Commission does not affect the ultimate jurisdiction of the municipal LGUs over the project site as the

Council is largely a coordinating body of the efforts of the LGUs and the agencies which impact on the ecology of the Manila Bay. This is anchored in the Integrated Coastal Management Act (EO533) [60].

The creation of the Manila Bay Development Commission is still subject to the passage of enabling national statute at least some 2-3 years from end of 2021.

Concluding North Manila Bay Flood Protection Strategy, and early projects following from it, can find ample support in the Manila Bay Sustainable Development Masterplan for its proposed measures. For example, the Masterplan envisions the restoration of mangrove and tidal flat areas as part of the coastal defence and focuses on setback areas around the coastlines. Therefore, the Manila Bay Development Commission, as proposed in the Manila Bay Sustainable Development Masterplan seems to be the best vehicle for implementing the wider flood protection strategy, as shown in this report. However, the Manila Bay Development Commission will (most likely) not be established within 2-3 years. Therefore, this report will also propose a short-term institutional setting that will be able to execute pilot and early adaptation projects.

6.4.4 ABB-BP

The North Manila Bay communities are aware of the challenges in confronting the problems of their coastal towns singly. Accordingly, last 24 March 2017, eight LGUs formed the “Alyansa ng mga Baybaying Bayan sa Bulacan at Pampanga” (ABB-BP). This is an alliance to protect the coastal communities of the two provinces and establish, align and strengthen their adaptation capacities and efforts towards fluvial and coastal flooding for disaster resilience and protection of livelihood sources.

This alliance was formed through a Memorandum of Understanding among the political leaders attending that conference. Among the initiatives of this ABB-BP is the intent to create a “Great Wall of Mangroves” along the entire coastline of the two provinces. This initiative by the LGUs of the two provinces indicates that the local leaders have the notion of a cooperative effort among the affected municipalities. The ABB-BP, at this point, is a forum for the participating LGU; there is no formal cooperation arrangement among the LGUs’ operating offices. It is not clear if the current setup will be in place after the 2022 Elections.

6.4.5 Pampanga river basin committee

The PRBC is composed of the seven Central Luzon Provincial Governors, the two Mayors of Central Luzon’s Highly Urbanized Cities, Regional Directors of the NEDA, DA, DENR, DPWH, DILG, the respective heads of the NWRB, DENR-RBCO and NAPOCOR, and one representative each from the private sector and Non-Government Organizations within the Pampanga River Basin. Together with NEDA and DPWH they formulated the Pampanga River Basin Climate Responsive Integrated Master Plan [54]. Th

6.5 Proposed long-term institutional setting

The proposed long term institutional setting of this strategy will align with the Manila Bay Sustainable Development Masterplan and Climate Responsive Integrated Master Plan for Pampanga River Basin, which means that any plans/projects will be recommended to the Manila Bay Development Commission, which will check the plans and will analyse and propose for funding solutions.

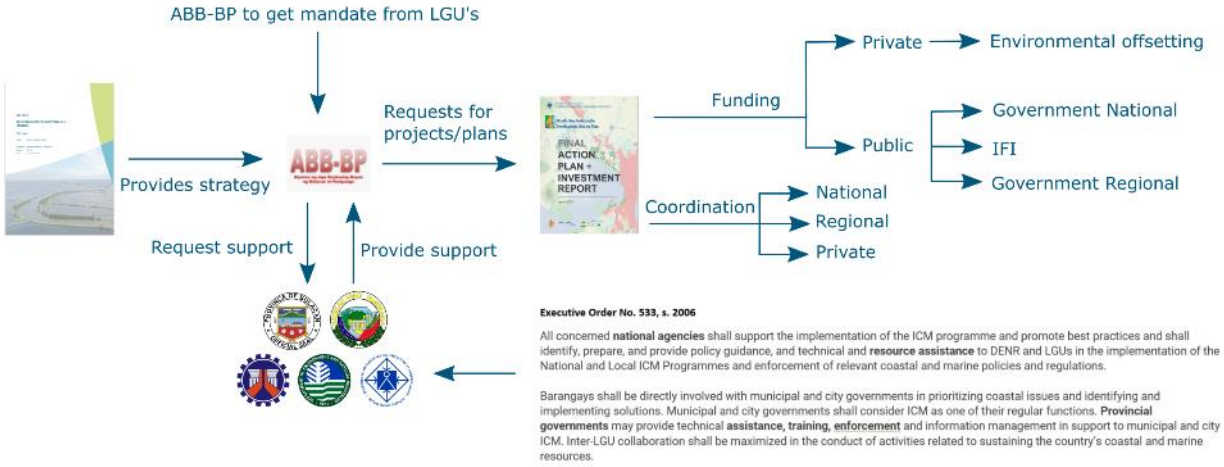


Figure 6-2: Proposed long term institutional set-up

The organizational structure of the proposed set-up in Figure 6-2 is shown in in detail in Appendix 5. The ABB-BP is an existing grouping of the ten towns and municipalities and two provinces which cover most of the project site.

- The North Manila Bay Flood Protection Strategy will provide the basis for the ABB-BP to request for projects and plans. The first projects and plans will be based on direct implementation of some of the plans proposed in this strategy. After some projects have been executed based on this strategy new plans/projects can be developed. The ABB-BP will also make sure that all local stakeholders, such as fisherfolks, are included in the decision making.
- The ABB-BP has a lack of mandate and resources.
    - The mandate of the ABB-BP has to be updated to make decisions on which projects within its constituency will be recommended for execution. This is only possible if the ABB-BP is still active after the 2022 elections. Otherwise, there needs to be a new/other institutes that represents all LGU's in the North Manila Bay area.
    - The ABB-BP currently does not have the funding or resources to make these decisions. Provincial funds or other supporting funds are available according to the Integrated Coastal Management Act (EO533) [60]. These funds will need to be requested, in which this strategy can act as a basis.
    - With the supporting funds, the ABB-BP can request or further develop projects and put in the requests with the Manila Bay Development Commission.
- The proposed Manila Bay Development Commission is responsible for funding and coordination of the project.
- For execution, the ABB-BP will champion the project with external technical guidance support and provide a long-term sustainability and maintenance plan.

6.6 Proposed short-term institutional setting

The proposed short-term institutional setting is focused on the early execution of (pilot) projects. It assumes that the Manila Bay Sustainable Development Masterplan and the proposed Manila Bay Development Commission are not yet operational. As the 2022 elections in May will be of great impact on the institutional setting this short-term setup is based on execution after the election. Therefore two scenarios are reflected:

1. ABB-BP will be in effect after 2022 elections
2. ABB-BP will not be in effect after 2022 elections

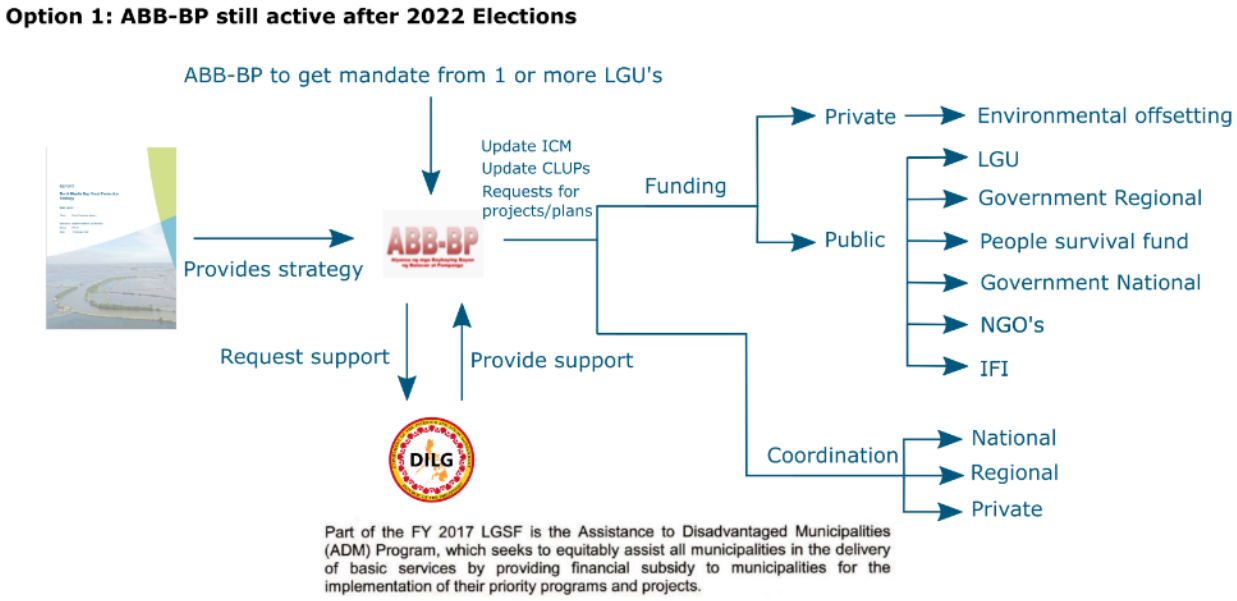


Figure 6-3: Short-term Institutional setup with ABB-BP in place after elections

Figure 6-3 shows the short-term institutional setup for scenario 1.

- The North Manila Bay Flood Protection Strategy (this study) provides the basis for the ABB-BP to
  - Arrange extended mandate from the LGU's in the North Manila Bay Delta;
  - Request support under the Local Government Support Fund-Assistance to Disadvantaged Municipalities from DILG [61]; and
  - Update ICM/CLUPs and subsequently request funding for projects.
- The ABB-BP will have a coordination/championing role for the implementation of the first (pilot) projects. There needs to be an update of the mandate of the ABB-BP to give them more "executing powers". This can be done via:
  - Additional corporation agreement between LGU's (Memorandum of Agreement); and
  - Registering the ABB-BP as legal entity

  The mandate will need to include that the ABB-BP will have continuous powers (cross election)
- The ABB-BP will need to have more resources/funds to act on the coordination/championing role. The ADM mechanism will provide for these resources/funds.
- ABB-BP will update the ICM and subsequently, the CLUP in parallel with the first (pilot) projects executed.
- The ABB-BP will firstly look for funds within the LGU's. During stakeholder meetings it was identified that LGUs would be able to fund projects up to 20-30 million PHP (to be validated after elections). If the first (pilot) projects are bigger (financial) or the LGU is not able to fund it the second option is to look for provincial funds or funds from the People Survival Fund. Alternatively, private funds or NGO funds can be researched.
- ABB-BP will also need to coordinate with the other agencies on any interfacing projects.

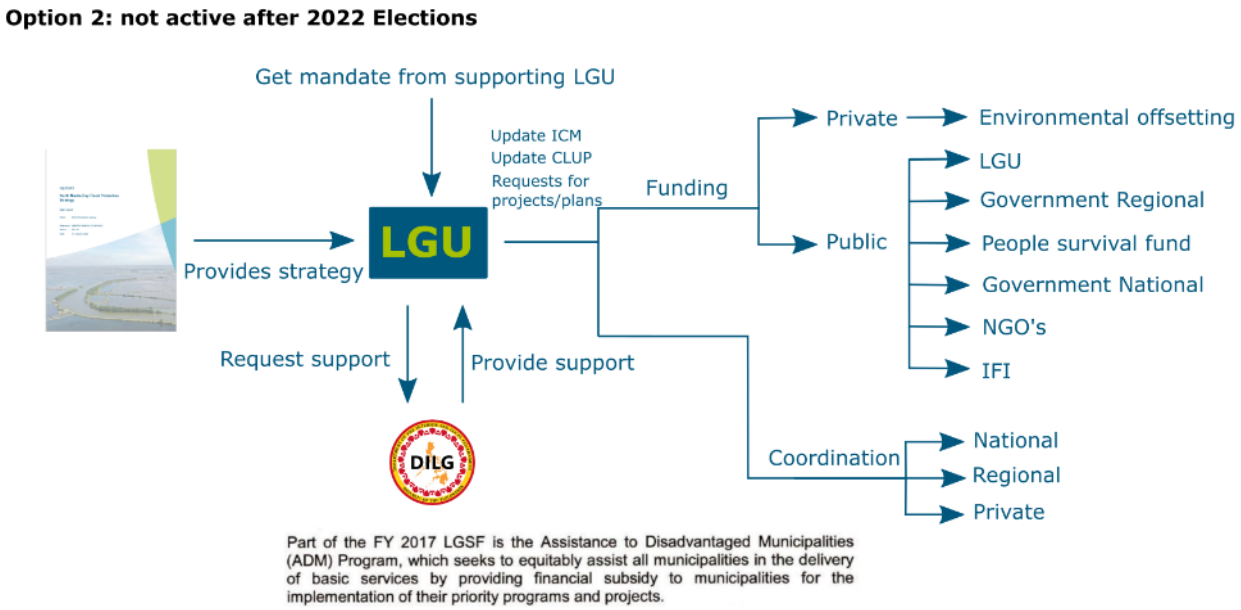


Figure 6-4: Short-term Institutional setup without ABB-BP in place after elections

Figure 6-4 shows the short-term institutional setup for scenario 2.

- The North Manila Bay Flood Protection Strategy (this study) provides the basis for a LGU to
  - Arrange extended mandate from the LGU's in the North Manila Bay Delta;
  - Request support under the ADM from DILG; and
  - Update ICM/CLUPs and subsequently request for funding for projects

  The particular LGU will need to have interest and support the flood protection strategy. It will need to be assessed after the elections which LGU would be best suited.
- The LGU will have a coordination/championing role for the implementation of the first (pilot) projects. There needs to be an update of the mandate of the LGU to give them more "executing powers". This can be done via:
  - Enhanced corporation agreement between LGU's
- The mandate will need to regulate that the LGU will have continuous powers (cross election).
- The LGU will need to have more resources/funds to act on the coordination/championing role. The ADM mechanism will provide for these resources/funds.
- LGU will update the ICM and subsequently, the CLUP before the first (pilot) projects will be executed.
- The LGU will firstly look for funds within the LGU's. During stakeholders meetings, it was identified that LGUs would be able to fund projects up to 20-30 million PHP (to be validated after elections). If the first (pilot) projects are bigger (financial) or the LGU is not able to fund it the second option is to look at Provincial funds or the People Survival Fund. Alternatively, private funds or NGO funds can be researched.
- LGU will also need to coordinate with the other agencies on any interfacing projects.

7 Funding

Another institutional weakness is the funding sources and mechanisms for any proposed flood management solution. Currently, the funding – and implementation – of major flood abatement projects are provided by the national government and from grants and loans from multilateral and bilateral foreign sources. Aside from that DENR under its Enhanced National Greening Program is also active in supporting the activities of the municipalities to develop the mangrove areas in the North of Manila Bay. The provincial and municipal LGUs also participate in these activities by providing the maintenance.

However, the ones most affected by the flooding are the people and small businesses with the least resources to realize long-term and permanent solutions to the problems associated with flooding. The municipal and provincial governments in the North Manila Bay heavily rely on the national government and the Office of the President, usually through representation to the Regional Development Council. Acquiring budget via this route requires use of political skill and capital on the local chief executives as they have to compete with the needs of other LGUs in the region.

Examples of large-scale projects carried out:

- In 2016, the government – through the DPWH – launched its PHP 2 Billion projects to build a 40 km levee to protect six towns of Pampanga. This included the takeover of fishponds at the cost of PHP 10 Million.
- PHP 20 Billion to rehabilitate the Pampanga Riverbank Dike to protect the region from Apalit to Arayat municipalities.

It has been observed that in most flood protection works, the focus is on the capital expenditure costs (CAPEX) and less so on the life cycle costs of a project. In order for an area to grow economically, life cycle costs are very important. This is where Nature-based Solutions can play a vital role; the solutions proposed have cheaper life cycle costs than traditional engineering solutions. This fact should be a catalyst for funding and should raise the interests of various agencies. On the back of this, this strategy advises updating the DWPH design standards with an engineering guideline for Nature-based Solutions, see Appendix 4.

It is important to note that the budgetary cycle in the Philippine government requires new budgets to be applied before November of each year. Any funding strategy routed through the Philippine government should therefore be submitted before November 2022.

The following sections provide alternatives for funding of Nature-based Solutions in the North Manila Bay area.

7.1 Option 1: Integrated Coastal Management

The current existing frameworks can be the source of funding for the Nature-based Solutions projects, as shown in this strategy. As reported in Section 6.4.2, the Integrated Coastal Management policies should provide support and funding from national agencies such as DENR and DPWH. There are obvious problems with this route, as explained in this strategy, of which the most important problem is that the LGUs do not have the capacity to request/process funding/support applications. This strategy will help in providing the theoretical basis. But still, the LGUs will need to be proactive and look for contact with the national agencies.

Estimated implementation difficulty: hard
Estimated implementation lead time: 4 years
Estimated budget size: Big (10-20 B PHP)

7.2 Option 2: DPWH infrastructure project

DPWH has ongoing projects in Bulacan and Pampanga such as roads and dredging activities. DPWH also completed several big flooding protection schemes in the region. During the stakeholder meetings DPWH expressed their interest in the implementation of Nature-based Solutions and promised active follow/assessment on any requests received.

Estimated implementation difficulty: medium
Estimated implementation lead time: 2 years
Estimated budget size: Big (10-20 B PHP)

7.3 Option 3: LGU-funded projects

LGUs are also able to bear the costs of self-developed projects. During stakeholder meetings, it became clear that some LGUs would be able to fund projects up to sizes of about 20-30 M PHP. This would be a viable option for the implementation of small-scale pilot projects. Also, it is expected that the road to approval of the project is less complex.

Estimated implementation difficulty: Easy
Estimated implementation lead time: 1 year
Estimated budget size: Small (<30 M PHP)

7.4 Option 4: People's Survival Fund

The People's Survival Fund (PSF) was created by Republic Act 10174 as an annual fund intended for local government units and accredited local/community organizations to implement climate change adaptation projects that will better equip vulnerable communities to deal with the impacts of climate change. LGUs can apply via an application portal for funding, they will need to submit financial statements and a basis for the plan. The basis could be this strategy.

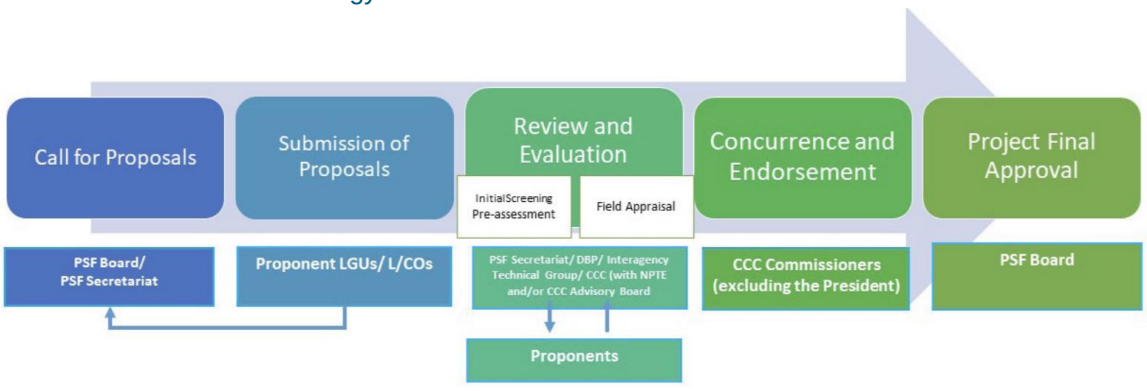


Figure 7-1: People survival fund proposal application

Estimated implementation difficulty: Easy
Estimated implementation lead time: 2 years
Estimated budget size: Medium (up to 200 M PHP)

7.5 Option 5: International financial institutions, Overseas grants and loans

Overseas Development Assistance (ODA) and bilateral and multilateral grants can also be the source of funding. It is a fairly common mechanism in the Philippines that funding like this is used for bigger projects or used as a mixed of grants and loans. This strategy can be presented to the IFI's such as ADB and WB, and it might be the basis for further development/funding from their side. ADB also has the possibility to submit unsolicited proposals and the DENR as the Focal Point proposing grants from the Global Environment Facility (GEF) to the Philippines.

Another example is the Carbon Credit Facility of the United Nations. Mangroves and intertidal mudflats are far superior in sequestering carbon than e.f. Terrestrial forests and, as such, an attractive candidate for carbon credit. This mechanism is not yet firmly established in the Philippines and may require a partnership through DENR or the Climate Change Commision with an entity already accredited with the U.N. Facility. This is also connected to the Green Climate Fund which support themes such as improved resilience in vulnerable communities and climate-resilient ecosystems

Estimated implementation difficulty: Medium to Hard
Estimated implementation lead time: 2- 5 years
Estimated budget size: From small to large (< 50 M to >5 B PHP)

7.6 Option 6: Private funding

Most of the publicly available Environmental Impact Statements provide a strategy that is called "environmental offsetting," practically meaning that any impact of such a project gets mitigated in a different area. This is the case for the New Manila International Airport. The offsetting targets shall align with the creation of habitat and ecosystems restoration which complement flood protection through the use of Nature-based Solution tools and methods.

Another example of private funding is carbon crediting where multinational companies try to offset their carbon footprint by dealing with carbon credits. This also makes carbon credit funding a financing source, or even a possible financial model for LGUs. As discussed earlier in the report, mangrove and mudflat restoration as tools of Nature-based Solutions can be leveraged for carbon credit funding.

Estimated implementation difficulty: Medium- Hard
Estimated implementation lead time: 2-5 years
Estimated budget size: Varying

8 Nature-based Solutions

Nature-based Solutions address infrastructural needs, offer protection from climate impacts and act as hazard mitigation tools. There are multiple definitions of Nature-based Solutions available. Here, we follow the definition from IUCN [62]:

*Nature-based Solutions are **actions** to protect, sustainably manage, and restore natural and modified ecosystems that **address societal challenges** effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*

Principles with this definition are that Nature-based Solutions:

1. Embrace nature conservation practices;
2. Can be implemented alone or integrated with other solutions;
3. Are determined by site-specific natural and cultural contexts, based on traditional, local, scientific knowledge;
4. Produce societal benefits in a fair and equitable way, in transparent and broad participation;
5. Maintain biological and cultural diversity and the ability of ecosystems to evolve over time;
6. Are applied at the scale of the landscape or seascape;
7. Recognize and address the trade-offs, between economic benefits versus a full range of ecosystem services;
8. Are an integral part of the overall design of policies, and measures and actions, to address a specific challenge.

System understanding is the key to successful implementation. In-depth knowledge about the physical system (biotic and abiotic) as well as the socio-economic system and the ecosystem services and benefits and governance context is essential to identify potential win-win situations. Once these win-win situations are identified, a multidisciplinary team can work in close collaboration with stakeholders on a design that benefits society, biodiversity, and the economy. Nature-based Solutions can also be applied in combination with traditional civil engineering/landscaping solutions.

In this section, an overview is given of different Nature-based Solutions that may be suitable for flood protection in the North Manila Bay Delta. Every feasible solution is described, and scores are given to indicate the main benefits and downsides of the different Nature-based Solutions.

8.1 Method for assessing the Nature-based Solutions

In the next paragraphs, different solutions that may be suitable for different locations in North Manilla Bay Delta are described. The main benefits and downsides of the different solutions are assessed as well. The assessment used the following criteria:

- Coastal flooding;
- River flooding;
- Storm surges wave attack;
- Property and livelihood damage;
- Environmental impact;
- Institutional complexity;
- Social impact.

The assessment of the different criteria is further explained in Table 8-1.

Table 8-1: Nature-based Solutions Assessment Criteria

Icon	Criteria	Description	
	Coastal flooding	The extent to which the solution reduces coastal flooding (short-term, long-term or both).	
		++	Reduction of coastal flooding on a large-scale both on the short-term and long-term*
		+	Local reduction of coastal flooding or Reduction of coastal flooding on a large-scale but only on the short or long-term
		0	No significant impact on coastal flooding
		-	Small increase in coastal flooding
		- -	Strong Increase in coastal flooding
	River flooding	Extent to which the solution reduces river flooding and siltation related to river flooding.	
		++	Reduction of river flooding on a large-scale both on the short-term and long-term*
		+	Reduction of river flooding on a large-scale but only on the short or long-term or Reduction of siltation due to river flooding
		0	No significant impact on river flooding
		-	Small increase in river flooding
		- -	Strong increase in river flooding
	Wave attack	The extent to which the solution reduces storm surge wave attack by dissipating wave energy and the extent to which the solution itself can withstand wave attack (durability).	
		++	Strong dissipation of wave energy and the solution itself can withstand wave attack
		+	Strong dissipation of wave energy but the solution itself cannot withstand wave attack or Moderate wave attenuation
		0	No significant impact on wave energy
		-	Increase in (vulnerability to) wave attack
		- -	Strong increase in (vulnerability to) wave attack
	Property/ Livelihood damage	Extent to which protection of properties and livelihood against flooding and siltation is increased (short-term, long-term or both). Loss of properties and livelihood related to the implementation of NbS (for example removal of housing to create space for the water) is considered as well.	
		++	Strong reduction of damage to properties/livelihood and the solution itself has little to no negative effects on existing properties or Strong reduction of damage to properties/livelihood and the negative effects of the solution on existing properties are small compared to the reduction of damage.
		+	Strong reduction of damage to properties/livelihood, but the solution itself has relatively large negative effects on existing properties or Moderate or only long-term reduction of damage to properties/livelihood
		0	No significant effect on properties/livelihood
		-	Increase in damage to properties/livelihood
		- -	Strong increase in damage to properties/livelihood
	Environ-mental impact	The extent to which measures contribute to**: - a sustainable coastal intertidal system (that can cope with effects of climate change and future economic developments) - a sustainable ecosystem with high biodiversity - a healthy living environment for people - reduction in greenhouse gases	
		++	Large-scale large positive environmental impact
		+	Small-scale positive environmental impact or Large-scale small positive environmental impact
		0	No significant environmental impact or Both positive and negative effects on the environment which are in balance
		-	Small-scale negative environmental impact
		- -	Large-scale negative environmental impact

Icon	Criteria	Description	
	Institutional complexity	The extent to which it is difficult to implement measures, enforce measures and create an impact with measures. Focus is on: - How many and which stakeholders are involved? - How many and which stakeholders will benefit from the measures? - How many and which stakeholders will be against the measures? - Can measures be implemented locally (and still have a significant impact)? - Will stakeholders experience clear short-term benefits from the solution? (instead of invisible or only long-term benefits)	
		++	Implementation is very easy, because relatively few stakeholders need to be involved, there are no significant negative effects for stakeholders and the solution offers clear benefits
		+	Implementation is easy because relatively few stakeholders need to be involved and negative effects are limited while short-term benefits are clear
		0	Implementation can be easy because relatively few stakeholders need to be involved and negative effects are limited but there are no clear short-term benefits
		-	Implementation is complex because many stakeholders need to be involved or the solution has significant negative effects for stakeholders
		- -	Implementation is very complex, because many stakeholders need to be involved and the solution has significant negative effects for stakeholders
	Social impact	Effect on communities and the well-being of individuals and families including effects on livelihood (income). Focus is on: - Is there a long-term or short-term benefit? (sustainability) - How many and which people benefit? - Negative effects due to removal/replacement of housing to create space Effects of a reduction in flooding/wave attack are not considered.	
		++	Large-scale long-term and short-term benefits for the community and livelihood (positive effects strongly outweigh negative effects)
		+	Positive effects on the community and livelihood outweigh negative effects
		0	Positive effects on the community and livelihood do not outweigh negative effects OR No significant effect on community and livelihood
		-	Negative effects on the community and livelihood outweigh positive effects
		- -	Negative effects on the community and livelihood strongly outweigh positive effects

* Short-term = within 1-2 years, long-term = after 10-20 years

** The environmental impact strongly depends on the location where a solution is implemented and to what extent it fits within the natural system. For the scores, it is assumed that solutions are implemented at locations where negative impacts are limited as much as possible.

8.2 Nature-based Solutions assessment overview

Based on expert judgement, about 20 Nature-based Solutions are deemed to be feasible for the North Manila Bay Delta area. These solutions are assessed based on the criteria mentioned in Table 8-1. It has to be noted that this assessment is qualitatively done and meant to give a basis for an initial idea on which Nature-based Solutions may be best applicable at which locations. The actual scoring per location might differ, or the scoring can also be subject of combinations with other Nature-based Solutions or traditional civil engineering solutions. The scoring is based on the description as set out in Appendix 4, as the general application of Nature-based Solutions is very dependent on local characteristics and a systemic approach, the scoring should be seen as first indicator. Any applications of Nature-based Solutions should be based on further design efforts.

The Nature-based Solutions will be categorized according to the multilayer safety approach. It has to be noted that there is no “Emergency Management” Nature-Based Solution available. The multi-layer safety approach is a method for reducing disaster risk pioneered by the Dutch. It provides three (3) different approach levels - prevention, spatial planning, and emergency management (Figure 8-1). In the past, efforts were concentrated on prevention in the form of dikes and seawalls, which are often limited in applicability and feasibility. The multi-level safety approach shows the potential of the other levels, spatial planning and emergency management, to mitigate impacts of natural hazards.

Multi-Layer Safety Approach

The Multi-Layer Safety Approach explained by the Dutch Experts:

- Prevention – minimizing the probability of flooding (e.g. by structural measures like dikes, seawall and levees, but also non-structural measures like mangrove and beach nourishment);
- Spatial Planning – land use/urban planning to minimize damage casualties (e.g. by build restrictions and flood resilient structure/ building);
- Emergency management – (e.g. public awareness and early warning systems)

Figure 8-1: Multi-Layer Safety approach

Appendix 4 shows the fact sheets for the Nature-based Solutions, which provide the basis for the scoring.

Table 8-2: Nature-based Solutions assessment overview

#	Nature-based Solutions	Nature-based Solutions scoring						
								
1	Shellfish reefs	0	0	+	0	+	++	++
2	Enhanced breakwaters	0	0	++	+	-	+	+
3	Double dike system	++	++	++	++	++	-	+
4	Sediment transfer (reuse of dredged material)	+	+	+	+	+	-	+
5	Mangrove rehabilitation	+	0	++	++	++	+	+
6	Wide inland green dike	++	++	+	++	0	-	+
7	Hanging and floating structures	0	0	+	0	+	++	+
8	Tidal flat restoration	+	0	++	+	++	-	0
9	Adaptive housing	0	0	0	++	0	-	++
10	Room for rivers	0	++	0	++	++	-	--
11	Retention basins	0	++	0	++	++	--	0
12	Green embankments	0	+	++	+	+	+	+
13	Rainwater collection and storage at buildings	0	0	0	+	+	++	+
14	Climate and water resilience planning CLUP updates	++	++	++	++	++	-	++
15	Increase sediment loading on the coastline	+	0	+	+	++	-	0
16	Prevent/regulate sediment extraction	+	+	+	+	++	--	0
17	Instigate, Maintain and Protect Nature-based Solution areas	++	+	++	+	++	--	++
18	Nature-based Solutions awareness	+	+	+	+	+	+	+
19	River diversion	0	++	0	++	0	--	-
20	Update DPWH guidelines	+	+	+	+	+	+	0

Prevention	Spatial planning	Emergency management

9 Location selection

The location selection aims to pinpoint the areas most exposed to flood risks. A granulation of the wider North Manila Bay Delta area to identify specific locations at barangay levels is needed to acquire selection of proposed priority areas, for which Nature-based Solutions as flood protection are most applicable. This Section sets out the funnelling from the wider North Manila Bay area to local level in 6 steps.

9.1 Step 1: North Manila Bay

The “North of Manila Bay” as referenced to in this flood protection strategy can be described in its broadest sense as Pampanga River Delta and Angat River Delta which are part of the wider Pampanga River Basin. The Pampanga River Basin and Delta are shown in Figure 9-1.

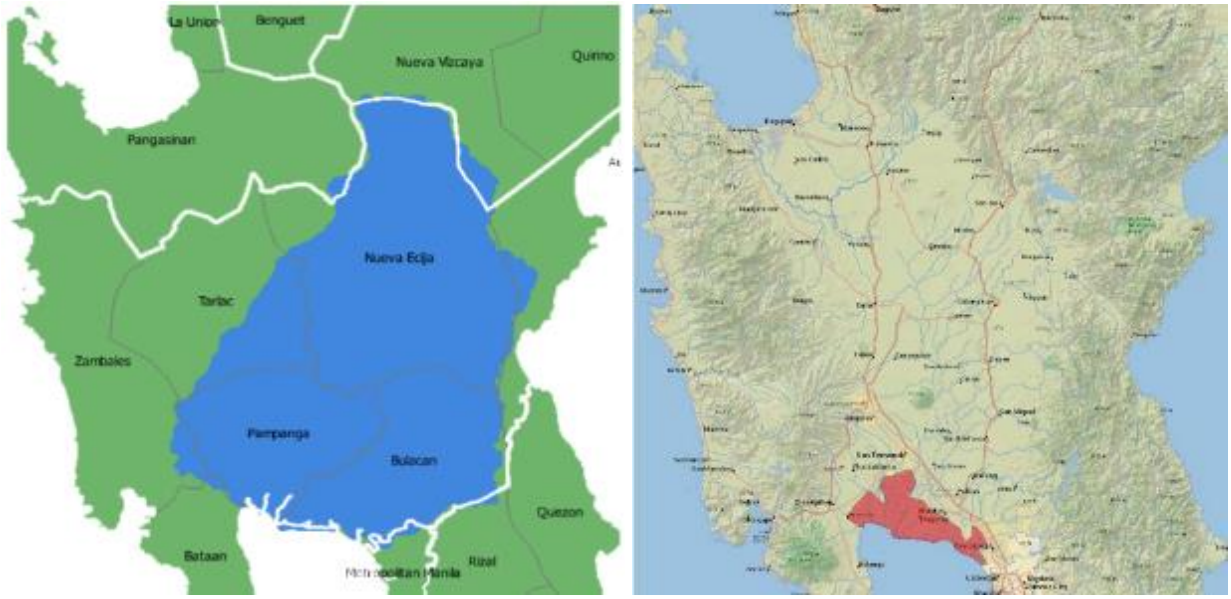


Figure 9-1: The Pampanga River Basin (left, blue) [10] and the Pampanga Delta (right, red)

The focus area of this Flood Protection Strategy is the coastal cities and municipalities of Pampanga and Bulacan, primarily south and along the Coastal Line of Defence (see Figure 9.4). The steps below describe how the granulation is achieved.

9.2 Step 2: Coastal Line of Defence

The Manila Bay Sustainable Development Masterplan proposes a concept named the ‘Coastal Line of Defence’ (CLD) which is based on the Report on Manila Bay Considerations on Coastal Protection [22]. In summary, the CLD is to be the basis for distinguishing:

- Areas that can be developed and protected (based on cost-benefit analysis);
- Areas that are too costly to improve and protect in the long run - thus retreat is inevitable to ensure the long-term security of people exposed to flooding and avoid loss of investments in development and flood protection that are likely to be inundated in the future; and
- Areas with a high potential to restore natural resources and habitats and to achieve goals related to habitat restoration and carbon emissions/storage.

As the scope of the North Manila Bay Flood Protection Strategy focuses on the coastal area of North Manila Bay, the philosophy regarding the Coastal Line of Defence is that, in line with [22], existing population

centres that currently lie outside of the Coastal Line of Defence will need to be provided protection. The Coastal Line of Defence itself will need to provide protection for the population centres that lie more upstream in the delta. The North Manila Bay Flood Protection Strategy will focus on devising a strategy for the locations that:

- Include towns and areas along the Coastal Line of Defence
- Lie between the Coastal Line of Defence and the current coastline.

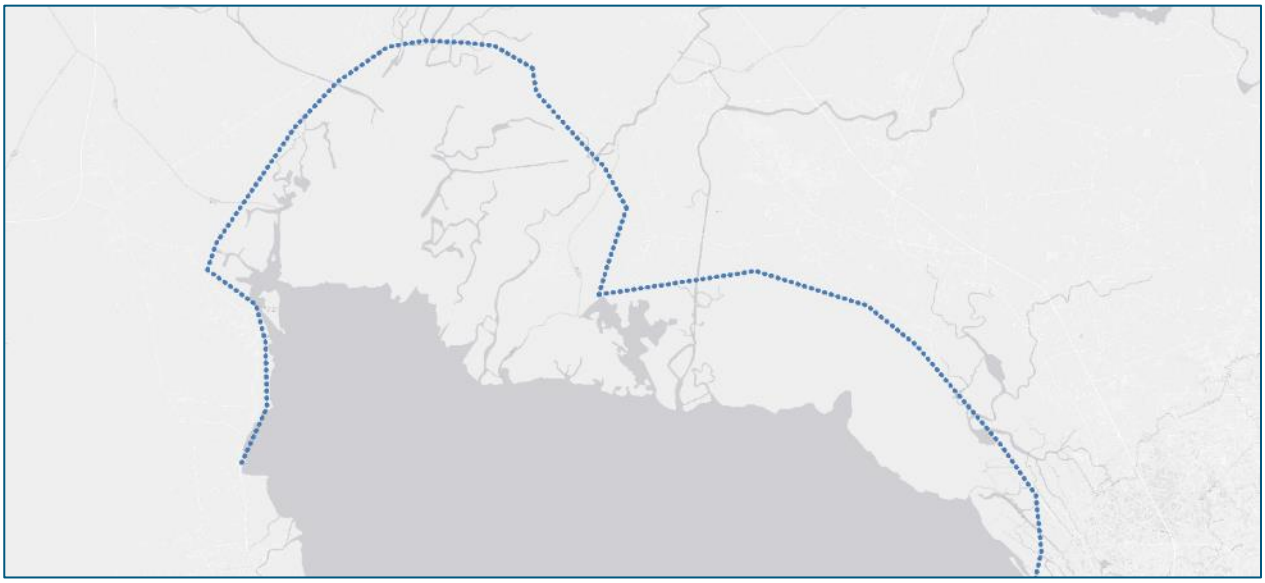


Figure 9-2: Coastal Line of Defence

9.3 Step 3: Provinces

The scope of the North Manila Bay Flood Protection Strategy is limited to the Provinces of Pampanga and Bulacan. The Coastal Line of Defence also impacts Bataan and NCR Third District, but these were excluded from the scope of this strategy.

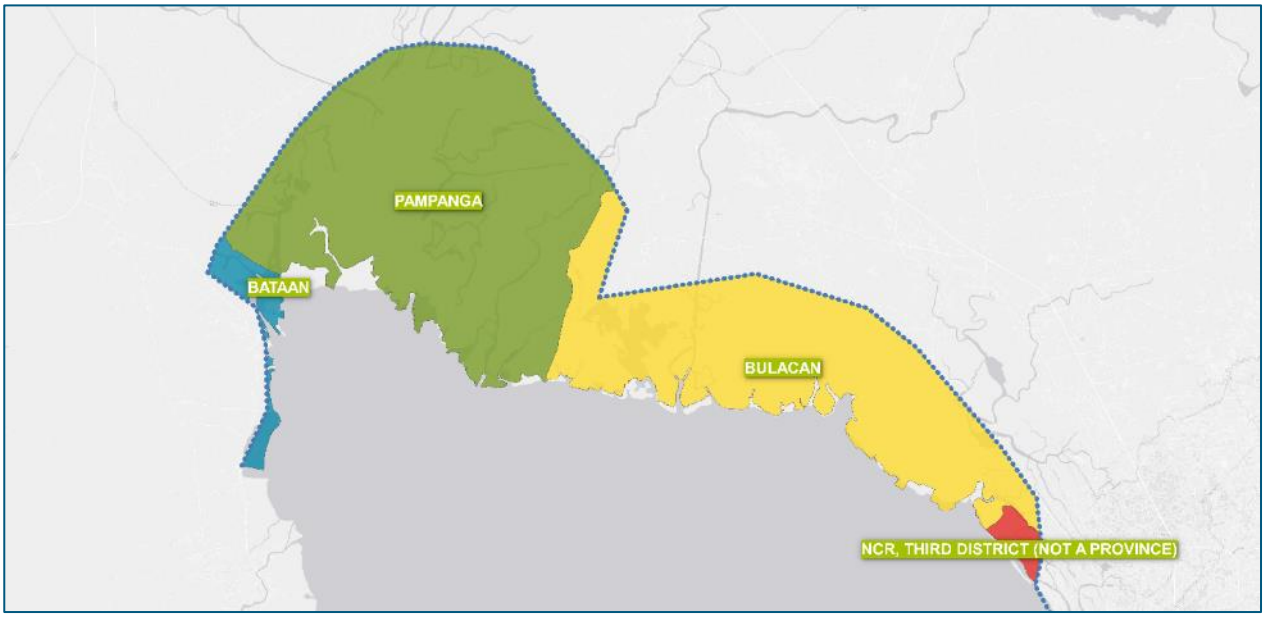


Figure 9-3: Provinces within Coastal Line of Defence, Pampanga green, Bulacan yellow

9.4 Step 4: Population centres along or inside CLD

The following LGUs within the Provinces of Bulacan and Pampanga are crossed by the Coastal Line of Defense and are adjacent to the coastline:

Bulacan	Population Centres (Barangays)
Bulacan	Bambang
Malolos	Pamarawan
Paombong	Binakod, Masukol, Santa Cruz
Hagonoy	Pugad, Sagrada Familia, San Pablo, Tibaguin
Pampanga	
Masantol	Bagang, Balibago, Bebe Anac, Bebe Matua, Bulacus, San Agustin (Caingin), Santa Monica (Caingin), Cambasi, Malauli, Nigui, Palimpe, Puti, Sagrada (Tibagin), San Isidro Anac, San Pedro, Santa Cruz, Santa Lucia Wakas, Sapang Kawayan, Sua
Macabebe	Consuelo, San Esteban, and Dalayap
Sasmuan	Batang 1st, Batang 2nd, Mabuanbuan, Malusac, San Antonio, San Pedro, Sabitanan
Lubao	Bancal Sinubli, Bancal Pugad, San Jose Gumi, Santa Teresa 2nd

Population centres are defined in Figure 9-4.

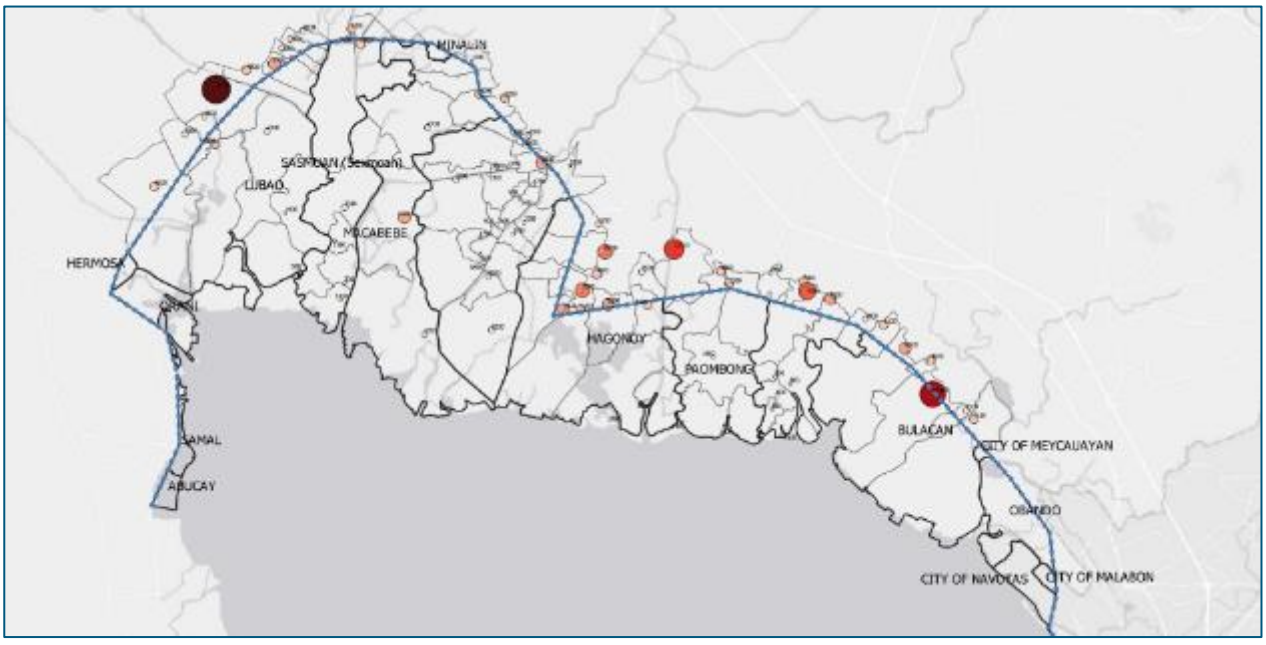


Figure 9-4: Location of Local Government Units included in the Flood Protection Strategy

As mentioned in step 1, the flood protection strategy will be focused on the population centres located between the Coastal Line of Defence and the current coastline to provide safety for the people who live there. Population centres along or inside the CLD are defined as a group of priority locations.

9.5 Step 5: Population centres outside CLD

The Manila Bay Sustainable Development Masterplan proposes to protect the current population centres along and inside the Coastline of Defence. For the population centres outside of the CLD it is acknowledged that for the bigger population centres (such as Macabebe), it is not feasible to relocate the whole population centre in the near future. Therefore, population centres outside but along the CLD are defined as a group of priority locations. In line with the Manila Bay Sustainable Development Masterplan the aim is to motivate inhabitants to move/relocate more inland, as due to sea-level rise and land subsidence, the area is not suited and sustainable for further urban development. New infrastructure developments will need to be discouraged while nature-based flood protection will be provided following the principles for the restoration of the coastal intertidal system, this will provide short-term solutions for inhabitants living in these areas. Nature-based Solutions will be focussed on measures that have a direct positive effect on the safety, livelihoods and sustainability of the living environment (ecosystems, natural resources and biodiversity) as these are interconnected. Implementing these solutions will benefit the resilience of the inhabitants of these areas who usually belong to the most vulnerable population groups.

9.6 Step 6: Livelihood and Infrastructure

This step is intended to determine the primary form of livelihood and infrastructure within the North Manila Bay project scope. This will be beneficial for assessing the appropriate flood protection strategy that will complement not only their primary source of living but also the existing major structures in the community. For example, mangrove belts can be applied in backshore fishponds, while inland earth dikes protect urban infrastructure. Table 9-1 summarises the identified livelihood and infrastructures per municipality.

Table 9-1: Primary livelihood and infrastructures for each key location

Province	Municipality	Livelihood/Infrastructure
Pampanga	Macabebe	Pampanga river outfall (Macabebe road)
Bulacan	Hagonoy	Angat river outfall
Pampanga	Sasmuan	Pasac river outfall
Bulacan	Malolos	Paramaran river outfall
Pampanga	Macabebe	Macabebe fishponds
Bulacan	Hagonoy	Hagonoy fishponds
Pampanga	Lubao	Lubao fishponds
Pampanga	Sasmuan	Sasmuan fishponds
Bulacan	Paombong	Paombong fishponds
Bulacan	Malolos	Malolos fishponds


Figure 9-5: River outfalls in Macabebe (Pampanga), Hagonoy (Bulacan), and Sasmuan (Pampanga)

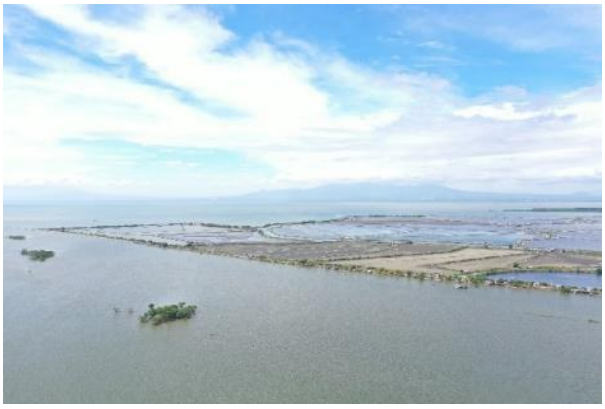



Figure 9-6: Fishponds in Macabebe (Pampanga), Hagonoy (Bulacan), Lubao (Pampanga), Sasmuan (Pampanga), Paombong (Bulacan), Malolos (Bulacan)

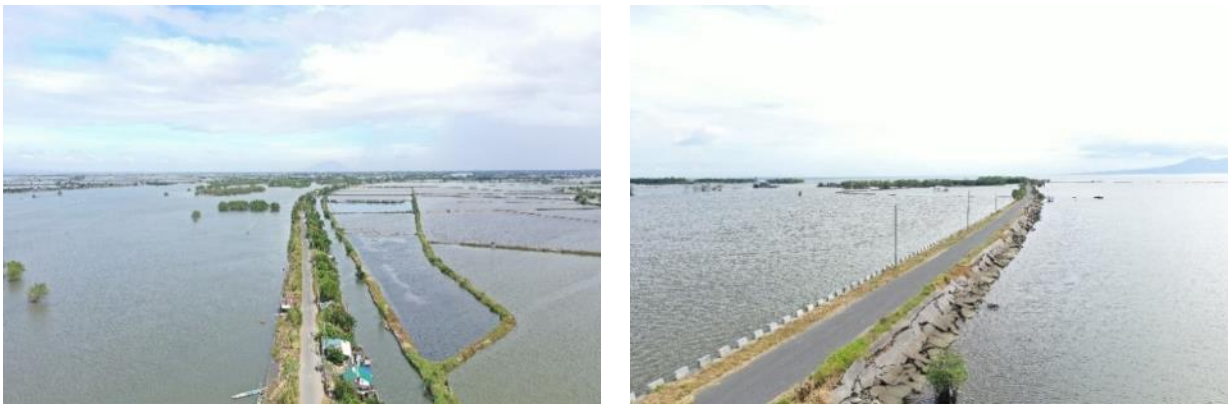


Figure 9-7:Roads in Barangay Consuelo, Macabebe, Pampanga (West & East)

Infrastructure and livelihood locations are defined as a group of priority locations.

9.7 Priority locations

The described location assessment process leads to 20 priority locations. Appendix 6 shows a detailed map of all priority locations, while Appendix 5 includes a detailed risk analysis per location. Figure 9-8 shows a snapshot of the maps included in the appendices.

Figure 9-8: Snapshot of priority location map

The overview of these assessments is given in Table 9-2. It has to be noted that the assessment of these locations is a combination of existing data, site surveys, and expert judgement by Royal HaskoningDHV and associated experts. The assessment may be different if a specific area within the location will be assessed or the other way around if the bigger area is considered. The purpose of this assessment is to reach an optimal flood protection strategy for the North Manila Bay area. The scoring is based on the description as set out in Appendix 5, as the general application of Nature-based Solutions is very dependent on local characteristics and a systemic approach; the scoring should be seen as first indicator. Any applications of Nature-based Solutions should be based on further design efforts.

Table 9-2: Prioritized locations assessment overview

#	Prioritized locations	Prioritized locations scoring						
Population centres near or outside of CLD (land wards)								
1	Bulakan Town	-	-	++	-	+	++	-
2	Hagonoy Town	-	--	++	--	--	+	-
3	Calumpit Town	++	--	++	-	--	++	-
4	Guagua Town	++	--	++	-	-	++	++
Population centres outside CLD (sea wards)								
5	Hagonoy villages	--	-	--	--	-	++	0
6	Masantol town and villages	-	--	++	--	-	++	-
7	Macabebe Town and villages	--	--	--	-	-	+	+
8	Lubao Town and villages	--	--	--	--	-	+	+
9	Paombong Town and villages	-	--	-	-	-	++	+
10	Malolos villages	--	--	--	--	0	+	-
Livelihood and infrastructure								
11	Pampanga river outfall	--	--	--	--	--	-	-
12	Angat river outfall	--	--	--	--	-	++	-
13	Pasac river outfall	--	--	-	0	+	+	0
14	Pamarawan river outfall	--	--	--	--	-	0	-
15	Macabebe fishponds	--	--	--	--	-	-	0
16	Hagonoy fishponds	--	--	--	-	-	++	-
17	Lubao fishponds	--	--	--	-	-	0	+
18	Sasmuan fishponds	--	--	--	-	++	0	0
19	Paombong fishponds	--	--	--	--	-	+	+
20	Malolos fishponds	--	--	--	--	0	+	-

Very high	High	Medium	Low	Very low
--	-	0	+	++
Very high likelihood *And/Or* Significant loss of life Property destroyed Livelihood destroyed	High likelihood *And/Or* Loss of life & injuries Property destr./damaged Livelihood dest./damaged	Medium likelihood *And/Or* Injuries Property destr. /damaged Livelihood damaged	Low likelihood *And/or* Injuries Property damaged Livelihood minor damage	Very low likelihood *And/or* No/ Minor Injuries Property minor damaged Livelihood intact

10 Solutions

Appendix 6 shows a map of possible solutions that have been identified. The map aims to have a unified strategy across Bulacan and Pampanga. The strategy stays clear from implementing solutions near the New Manila International Airport and at known internationally critically habitats for migratory species including fish and waterbirds such as at the Pampanga River, outfall, and coastal mudflats in Sta Cruz, Paombong, and Pamarawan- Caliligawan, Malolos. For the airport area, it is expected that this area will be subject to various landscape changes in the coming years. The map also aims to unify various strategies/plans that have been developed or are being undertaken at the moment:

- Manila Bay Sustainable Development Master Plan [1]
- Building with Nature Asia Landscape proposition [7]
- Wetlands Philippines Building with Nature Asia Landscape proposition (see Appendix 1)
- Potential Measures to reduce Fluvial and Tidal Floods in the Pampanga Delta [63]
- North Manila Bay Flood Protection Strategy (this report)

This North Manila Bay Flood Protection Strategy ties together the plans identified above but not the draft Biodiversity Off-set Management Plan for New Manila International Airport, which include the same coastal and near-near coastal areas as this Strategy. It adds to these an extensive assessment of root causes, stakeholder requirements, and institutional setting. The Nature-based Solutions proposed in Section 8 and the location selection in Section 9 provide the basis for the proposed solutions for the flooding problem in North Manila Bay area.

10.1 Background on proposed solutions map

This section gives an explanation of the map added in Appendix 6.

10.1.1 Retention

To have a significant impact on the amount of flooding, the people in population centres need to deal with a month-to-month basis approach. Creating a retention area near Calumpit between the Pampanga and Angat rivers is a solution. The retention area will need to have enough size to “cap” the flood levels for at least 1/1 per year return period river discharge. The capacity required for this in terms of area and depth for the retention basin needs to be further researched. The social impact of a retention basin is significant. The people and businesses currently residing in the area need to be relocated or provided tools to adapt to a situation where they experience more flooding. Due to the complexity and the costs associated with this, a retention area will not be nominated as a pilot area.

10.1.2 River diversion (Room for living space)

A significant (reduction) impact on the amount of flooding in Hagonoy (and other urban areas) can be achieved by creating a river diversion between Angat River and Pampanga River. However, the cumulative, environmental and social impacts needs to be assessed. This area between the Pampanga and Anget River is significantly less densely populated than the urban Hagonoy. The river diversion should incorporate wide flood plains to allow it to be “sold and funded” as a Nature-based Solution. The social impact(livelihood) is significant as a number of current fishponds will need to be converted

An alternative solution is allowing for river run-off through lowering/removing fishponds in the area, which is proposed as a part of the study by Van ‘t Veld [21].

10.1.3 River widening (Room for the river)

Recreating wider floodplains adjacent to the existing rivers is a solution to increase the rivers flow capacity and reduce the flood levels upstream. Currently, most of the original flood plains are either diked or converted to fishponds. Regulations on the expanding fishponds at the flood plains should be enforced by the LGU or where no policy regulations are in place; regulatory Ordinances needs to be issued.

10.1.4 Sediment trapping

Restoring the sediment balance to a situation ~100 years ago will allow for new sediment built-up along the shoreline. This sediment built-up will contribute to reduced coastal erosion and protect inland areas from wave attack and coastal surges. The protection from wave attack will also benefit the sediment's accretion speed, creating a cumulative effect. Additionally, the newly settled sediment will stimulate mangrove growth and contribute to mudflat restoration vital for livelihoods and biodiversity.

10.1.5 “Soft measures”

Soft measures are measures that do not require physical implementation. For the North Manila Bay area, the following measures are proposed:

- Focus on raising awareness and knowledge transfer of DPWH and other government agencies and LGUs and affected communities
- Support LGUs when creating CLUP or other water management policies, this strategy combined with the Climate Responsive Integrated Master Plan for Pampanga River Basin [54], should be the input.
- Include Nature-based Solutions tools in DWPH design guidelines and in DENR Mangrove Administrative Orders
- Cancel sediment mining and dredging permits in the foreshore area
- Giving more powers to ABB-BP.
- Free and prior consent relocation of informal settlers through incentives and other compensations
- Re-use of dredged river sediment materials

10.2 Possible Pilot: Pampanga River outfall

To provide an example project/location, the Netherlands Enterprise Agency wants to plan for a pilot location to be developed. One of the main issues with motivating Nature-based Solutions in the Philippines is a lack of good example projects; the construction of a pilot location may solve this problem. Moreover, the pilot location can be considered the first project arising out of this strategy and the wider Manila Bay Sustainable Development Master Plan. This chapter will discuss the layout, possible construction methodology, institutional arrangement, and conceptual cost estimates for a pilot location at the Pampanga River outfall.

The Pampanga River outfall is a location where various issues related to flood protection, natural habitats and protection of critical habitats come together. The river has been diked far from the original outflow (see Figure 3-5). Must of the mudflats and coastal mangrove forest are transformed into fishponds or fishpens, and the riverbed and foreshore seabed are being used as mining areas. The pilot aligns with the plans of the Building with Nature Asia Landscape proposition [7] and ongoing efforts by the DENR to declare the lower Pampanga River as a Critical Habitat which together seeks to restore natural habitats and protect ecosystems and biodiversity along the North Manila Bay coastline. The removal of fish pens/ponds also contributes to a direct reduction in flooding upstream, according to [21].

10.2.1 Layout

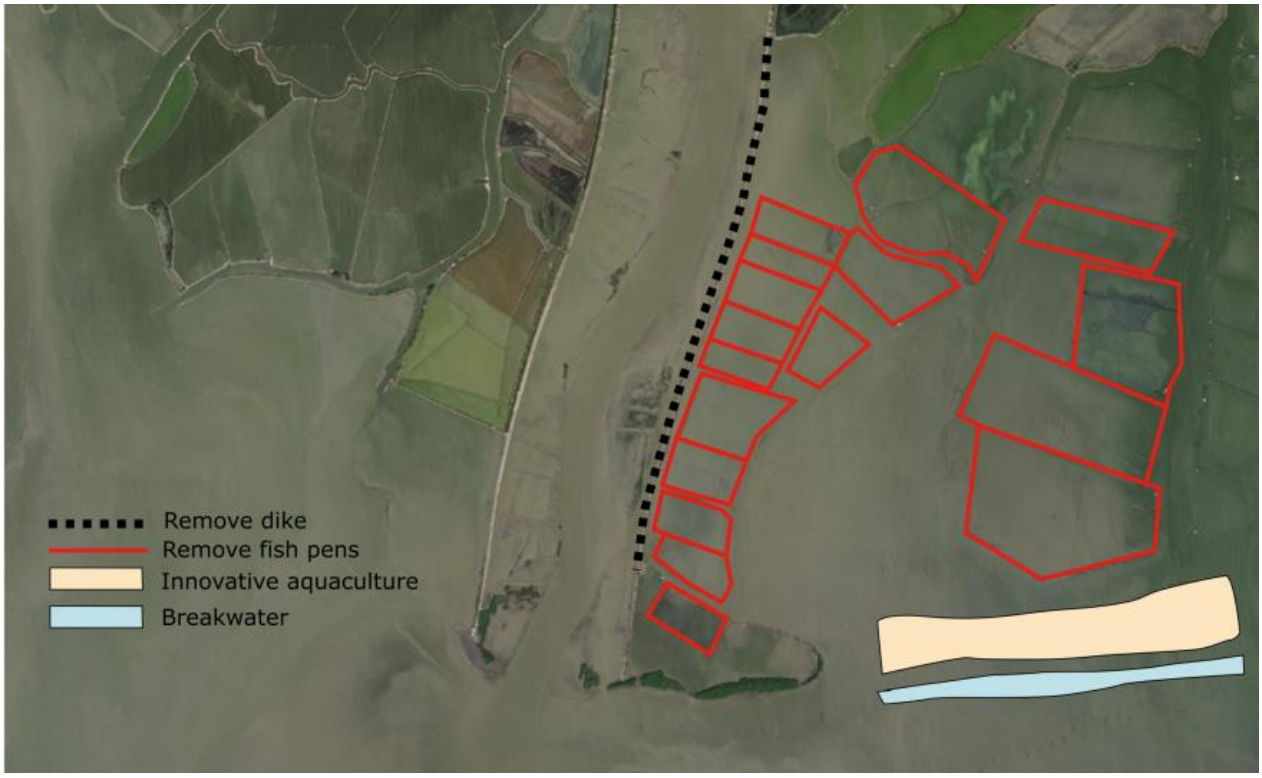


Figure 10-1: Pilot location Pampanga river outfall

Figure 10-1 shows the layout of the Pampanga River east bank.

- The first task will be to demolish the east bank dike. The main reason why the east bank is chosen is that the dike is already in an increasing deteriorating state, but the dike on the river's west bank is in a relatively good condition and used to access a provincial tourist recreation attraction and thus more institutionally complex to remove, if at all.
- There are currently about 20 fish pens (former fishpond operators) operating, as shown in the red line boxes The LGU will need to check if they have a valid permit, if not, they can be relocated immediately. If they have a valid permit, a relocation/ compensation plan needs to be made.
- The breakwater will be needed to kickstart and enhance the sediment trapping speed to recreate new foreshore/mudflats. This breakwater will need to be constructed, taking into account hydraulic loads and the shape of the subsoil (soft soil). As much as possible, the breakwater will need to be built from materials available within the North Manila Bay delta system, such as dredged materials, bamboo/wood and revetment re-use.
- Behind the breakwater (over time), the old fish pen locations will collect the sediment coming in from the Pampanga river (through the removed east bank dike When this process has started, the pilot can be extended to the fishponds situated more north to restore the Mangrove belt.
- As substantial portions of the river and its mudflats have been has been converted into fishponds, these need to be removed in certain areas and the owners compensated. Riverbank mudflat expansion in this area will also greatly benefit the very large number of migratory waterbirds of international importance present at the river most of the year

10.2.1.1 Removing east bank Pampanga River

The current maintenance state of the east bank is poor. The revetment is damaged severely, and various uncontrolled settlements have been observed.

Figure 10-2: Pampanga river east bank looking south towards fish pens (left) current state of revetment (right)

When removing the east bank, the concrete materials can be re-used as foundation or the breakwater construction.

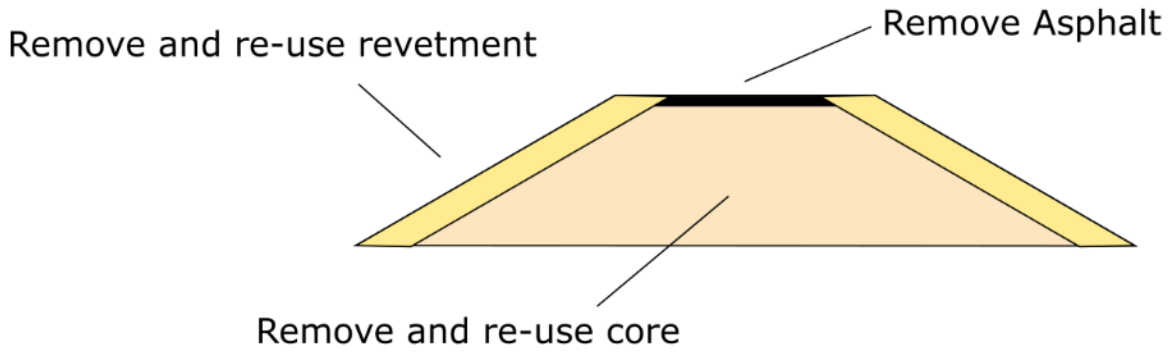


Figure 10-3: Schematic construction activities removing east bank of Pampanga River

Prior to removal geotechnical and concrete material investigations should be done to confirm if the soil and other materials are fit for re-use (contamination). The removal/demolition of the dike can be executed by “ordinary” excavators which excavate and transfer the materials into barges. The barges can be used to ship the material to the re-use location. The length of the dike to be removed is approximately 3500 meters.

Table 10-1: Existing dike geometry assumptions

Parameters	Value	unit
Crest witdh	10	[m]
Slope	2	[1:x]
Crest level	3	[m MSL]
Toe level	-1	[m MSL]
Armour thickness	0.3	[m]
Asphalt thickness	0.3	[m]
Length dike	3500	[m]

Approximately 20 fish pens (300 hectares) may need to be removed and/or relocated and compenstated. The LGU of Hagonoy will need to check current permits/consent in place for these fish pens to operate after which discussions on removal and relocation with the respective owners can start. Another option is to allow some fish pens to operate and monitor over time if there is any difference in siltation between operational and non-operational sites. This, however, may lead to “unwanted” siltation of operational fish pens.

Figure 10-4: Fish pen removal relocation

According to the conversations with local stakeholders, about 50% of fishponds in the area are non-operational due to the increased damages during flooding/typhoon conditions. The fish pen area is one such example

10.2.1.2 Building an enhanced breakwater

For the breakwater to have a proper design life, the soft soil underneath the breakwater will need to be replaced with a more stiff material (sand) foundation except in areas where former stone dikes still exists . This dredged material can be re-used on the north side of the breakwater to kick start the sedimentation process. If this is too expensive or no permits can be acquired for this type of construction, the breakwater can still be constructed. However, it will need regular maintenance after construction without foundation (every six months for the first five years, after that every two years) to compensate for settlement.

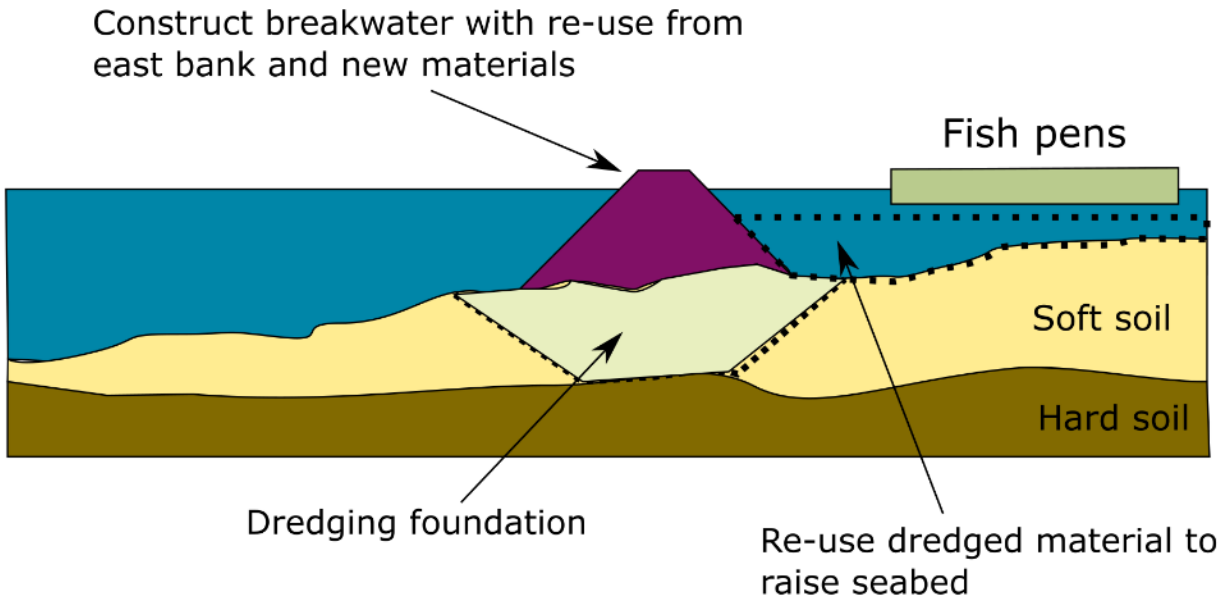


Figure 10-5: Breakwater construction

The breakwater itself can be constructed using material obtained from removing the east bank as core material. The revetments will need to be designed for the breakwater to withstand wave attacks during severe typhoon conditions (1/100 year return period event).

Table 10-2: Breakwater parameters

Parameters	Value	unit
Crest witdh	2	[m]
Slope	3	[1:x]
Crest level	3	[m MSL]
Toe level	-2	[m MSL]
Armour thickness	2	[m]
Length breakwater	1500	[m]
Dredging depth	8	[m]
Dredging width	30	[m]

10.2.2 Aquaculture solutions/innovations

To compensate for the loss in livelihood due to removal of the fish pens and promote an alternate way of livelihood, shellfish reefs and hanging structures (mussels/oysters) are proposed to be placed behind the breakwater. It is understood that the net profit of fish pen livelihoods are higher than of shells production. Any further plans should incorporate a strategy on compensating fishpond/fishpen owners and focussing shellfish production as livelihood for the lowest income earners.

Figure 10-6: Oyster farming [64] and mussel farming [65]

10.2.3 Institutional

Section 6.5 and 6.6 describe long-term and short-term solutions for an institutional setup that allows for the execution of a pilot project and subsequent maintenance of the pilot project. For this pilot location, it is important that after the May 2022 elections this strategy will be presented to the ABB-BP (if it is still active) and/or an elected supportive Mayor . Based on the support of the newly elected Mayor, support from the LGU can be obtained to execute the pilot project. If funded via the “traditional” route, the LGU will have to acquire funds from either DILG or DENR to increase its capacity to fund the project via ICM processes or DPWH budget request. Most feasible funding tracks would be a local LGU funded budget or the People’s Survival Fund.

10.2.4 Conceptual cost estimates

The following activities are foreseen to complete the construction of the outfall pilot

- Project Management
    - ABB-BP or LGU representative full time

- Stakeholder management
- Expert support (Nature based solutions)
- Expert support (Coastal engineering)
- Contracting
- Supervision

- Detailed Design
  - Basis of Design
  - Numerical river modelling to prove impact on flooding and show that removing the part of the dike does not have a negative impact
  - Numerical coastal modelling
  - Breakwater design
  - Aquaculture
- Surveys
  - Bathymetric
  - Geotechnical existing dike
  - Geotechnical breakwater
  - Material testing dike
- Construction
  - Demolish dike and re-use material
  - Dredge breakwater foundation
  - Built breakwater
  - Built aquaculture solutions

Table 10-3: Pampanga River outfall conceptual costs estimates

Project Management	$	177,000
Dike removal	$	576,000
Breakwater construction	$	2,520,000
Aquaculture solutions	$	541,000
Contingency (10 %)	$	381,400
Total costs (conceptual)	$	4,195,400

It is important that the LGU will budget for the maintenance of the solution after the construction is completed.

10.3 Possible Pilot: Masantol and Macabebe embankments

To provide an example project/location, the Netherlands Enterprise Agency prioritise the development of pilot locations. The reason is that a main issue motivating use of Nature-based Solutions in the Philippines is lack of good example projects together with a dearth of knowledge; the construction in a pilot location will contribute to reducing this issue if a synergetic approach is used This chapter discusses the layout, possible construction methodology, institutional arrangement, and conceptual cost estimates for a pilot location to construct green embankments in the Masantol and Macabebe areas. Much care with safeguards being in place is needed when it comes to implementation of Nature-based Solutions in Masantol (Pampanga river east bank) as this area includes internationally important habitats for more than 40,000 migratory waterbirds connected to the Sasmuan Coastal Critical Habitat and Ramsar site. located nearby. As such the DENR-BMB currently is working on declaring portions of Macabebe and Masantol as Critical Habitat under Philippine Law. The pilot may have to undergo the EIA process.

10.3.1 Layout

The current practice of constructing embankments involves lining relatively steep slopes with concrete for primary structures and for secondary structures such as fishponds they are constructed with bamboo poles with soil in between them. Due to settlement processes and concrete quality issues, these concrete “revetments” disintegrate rapidly, causing high maintenance costs. The solutions presented in this Section can be applied to various locations throughout the delta. For the Pilot in this report, an example location is used to motivate the implementation. Figure 10-7 shows a damaged section of an embankment that can be replaced by a green embankment.

Figure 10-7: Current embankment/revetment construction practice

The pilot will be closely aligned with the green embankments solution presented in Section 8. The core of the idea is that a more gentle sloping embankment profile combined with the correct usage of (natural) materials will provide much more flexible slope protection that requires less maintenance and significantly saves the design life of the embankment compared to the concrete lining.

Figure 10-8 shows the sequence of replacing existing damaged embankments.

- Firstly, the existing revetments will need to be removed, and the construction area will need to be cleared of all debris.
- During the design process, it will need to be determined, given the hydraulic conditions and expected settlements, what the expected natural slope (step 5) will be. Based on this, an appropriate width of the “berm” will need to be designed. This can range from 5 meters environments with less wave energy up to 15 meters on locations with higher wave impacts.

- During the design, it should also be calculated if a “clay deck” protection is sufficient protection against erosion or if additional rock armour scour protection is needed to guarantee the slope stability.
- The newly placed soil will need to be covered with coco nets to prevent erosion in the “pioneering” stages of the vegetation that will need to start growing on the embankment. However, the choice of vegetation ranges from mangroves and nipa palms at tidal-impacted dikes and a number of beach forest species on top of dikes in some areas.
- When the natural development of the slope kicks in, it is expected that the slope will change and take on an equilibrium profile formed by the wave action. This is normal, and the slope should be designed for this. The vegetation will form the erosion protection.

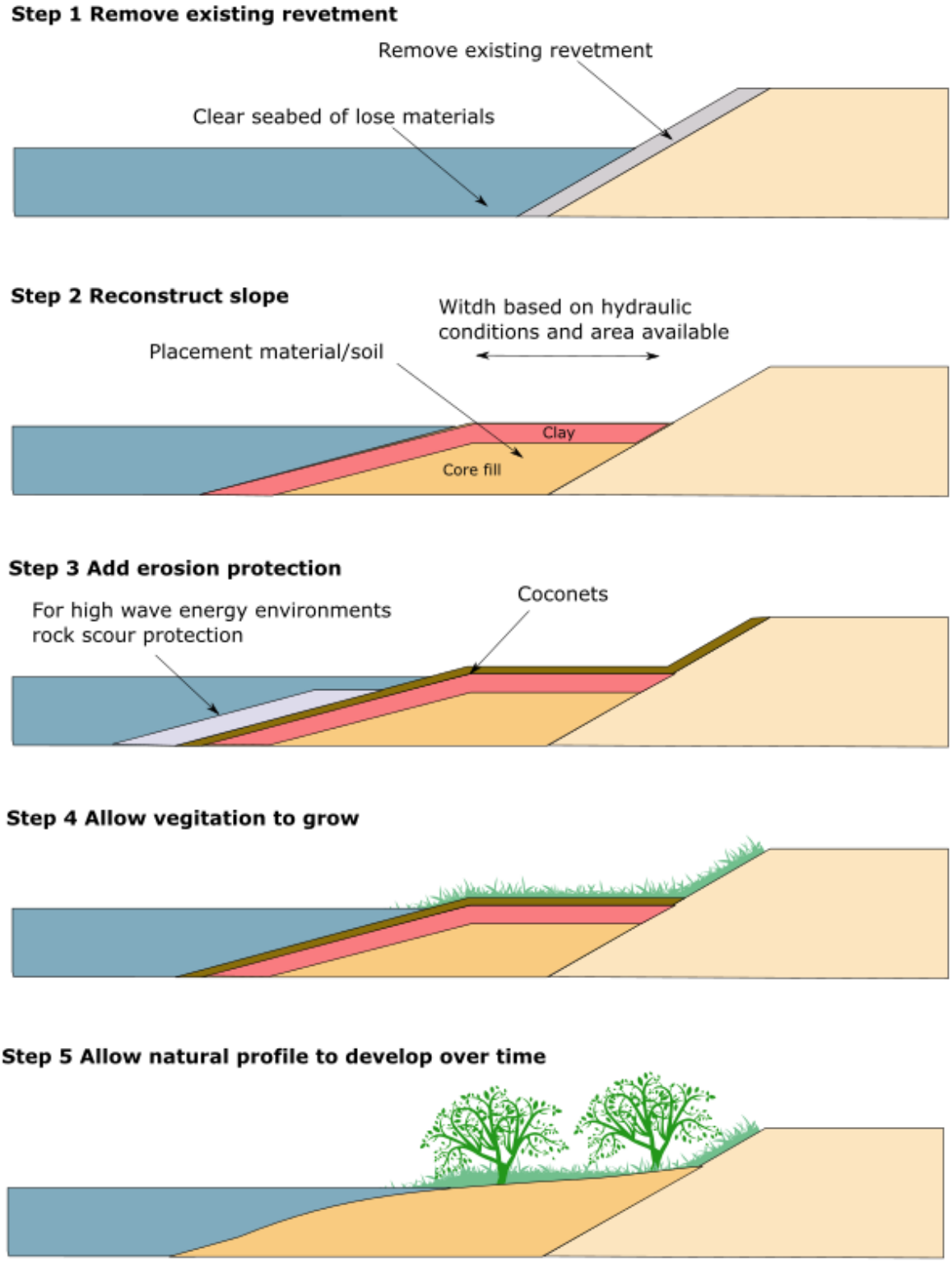


Figure 10-8: Existing revetment removal

10.3.2 Institutional

If funded, the LGUs of Masantol and Macabebe are both open for implementing these solutions funded). After the 2022 elections, the LGUs needs to assess if they are still willing to implement the Green Embankments and provide a list with possible locations in close collaboration with DENR-BMB as the area include internationally important habitats for migratory species. The LGU(s) will need to discuss with land owners about titling/land issues arising from the embankment extension. It would be good to select a location for the Pilot in which the sea/river ward extension of the embankment is on government titled lands, as all river banks 20 meter sea ward are public lands under the Water Code, there should be various locations available. The most feasible funding tracks would be a local LGU funded budget or the Peoples Survival Fund. This Nature-based Solutions Solution is an example of where trained local labourers from the community should have priority in executing the works.

10.3.3 Conceptual cost estimates

The following activities are foreseen to complete the construction of the outfall pilot

- Project Management
  - ABB-BP or LGU representative full time
  - Stakeholder management
  - Expert support (Nature based solutions)
  - Expert support (Coastal engineering)
  - Contracting
  - Supervision
- Detailed Design
  - Basis of Design
  - Wave impact assessment based on empirical calculations
  - Embankment design
  - Planting scheme
- Surveys
  - Bathymetric
  - Material testing dike
- Construction
  - Demolish Revetment
  - Supply core material and clay
  - Supply coronets
  - Planting

Table 10-4: Conceptual cost estimates green embankments (2,000 m)

Project Management	$	34,000
Revetment removal	$	77,000
Green embankment construction	$	603,000
Contingency (10 %)	$	60,300
Total costs (conceptual)	$	663,300

11 Bibliography

[1] National Economic Development Authority, “Manila Bay Sustainable Development Master Plan: Action Plan + Investment Report,” 2021.

[2] National Economic and Development Authority, “Manila Bay Sustainable Development Master Plan: Manila Bay Atlas,” 2021.

[3] M. Macdonald, “New Manila International Airport: Environmental and Social Impact Assessment Volume I - Project Description,” 2021.

[4] M. Macdonald, “New Manila Bay International Airport Environmental and Social Impact Assessment Volume II - Scoping and Methodolog,” 2021.

[5] M. Macdonald, “New Manila International Airport: Environmental and Social Impact Assessment Volume IV - Stakeholder Engagement Framework and Grievance Mechanism,” 2021.

[6] N. E. a. D. Authority, “Manila Bay Sustainable Development Masterplan: Annex 1 Integrated Coastal Zone Management Framework”.

[7] Wetlands International, “Building with Nature Asia landscape propostion Philippines,” 2021.

[8] CNN Philippines, “San-Miguel-Bulacan-airport-photos.,” [Online]. Available: https://www.cnnphilippines.com/business/2019/8/9/San-Miguel-Bulacan-airport-photos.html.

[9] “The study on integrated water resources management for poverty alleviation and economic development in the pampanga river basin,” JICA/CTI, 2011.

[10] Department of Environmental and Natural resources, “PAMPANGA RIVER BASIN,” [Online]. Available: https://riverbasin.denr.gov.ph/river/pampanga.

[11] G. S. Jacinto, I. B. Velasquez, C. L. Villanoy and F. B. Siringan, “Biophysical environment of Manila Bay—then and now,” *The Environment in Asia Pacific Harbours,* pp. 293-307, 2006.

[12] K. Rodolfo and F. Siringan, “Global sea-level rise is recognised, but flooding from anthropogenic land subsidence is ignored around northern Manila Bay, Philippines,” *Disaster,* vol. 30, no. 1, pp. 118-139, 2016.

[13] F. Mialhe, Y. Gunnell, C. Mering, J. C. Gaillard, J. G. Coloma and L. Dabbadie, “The development of aquaculture on the northern coast of Manila Bay (Philippines): an analysis of long-term land-use changes and their causes.,” *Journal of Land Use Science,* vol. 11, no. 2, pp. 236-256, 2016.

[14] V. M. Morin, P. Warnitchai and S. Weesakul, “Storm surge hazard in Manila Bay: Typhoon Nesat (Pedring) and the SW monsoon,” *Natural Hazards,* vol. 81, no. 3, pp. 1569-1588, 2016.

[15] M. A. Bucay, T. A. Abrina, J. Gan and M. F. Cosico, “A Technical Analysis on the Manila Bay Dolomite Beach Reclamation Project,” *Philippine Journal of Public Policy,* Vols. Interdisciplinary Development Perspectives, 2021, 2022.

[16] A. E. Jensen, “Internationally Important Waterbird Sites in Manila Bay the Philippines,” Wetlands International and IUCN National Committee of the Netherlands, 2018.

[17] PEMSEA and MBEMP TWG-RRA, “Manila Bay: Refined Risk Assessment,” GEF/UNDP/IMO Regional Programme on Partnerships in Environmental Management for the Seas of East Asia, 2004.

[18] R. e. al., 2020.

[19] U.S. Army Corps of Engineers, “International Guidelines on Natural and Nature-Based Features for Flood Risk Management,” Nov, 2021.

[20] G. R. P. o. B. Partnerships, “Manila Bay: Refined Risk Assessment,” 2004.

[21] A. (. v. '. Veld, “Potential Measures to reduce Fluvial and Tidal Floods in the Pampanga Delta,” 2015.

[22] Deltares, “Manila Bay Sustainable Development Master Plan, Annex 16; Manila Bay, Considerations on Coastal protection,” 2019.

[23] C. C. S. Luma-ang, “The analysis of storm surge in manila bay, the philippines,” Hydrography Branch, National Mapping and Resource Information Authority, (Philippines), 2020.

[24] J.-P. G. (. A. P. Nerilie Abram (Australia), “Chapter 1: Framing and Context of the Report Supplementary Material,” IPCC, 2021. [Online].

[25] NASA, IPCC, “IPCC AR6 Sea level rise projection tool,” NASA, 2021. [Online]. Available: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool?psmsl_id=145.

[26] K. S. R. a. F. P. Siringan, “Global sea-level rise is recognised,but flooding from anthropogenic land subsidence is ignored around northern Manila Bay, Philippines,” 2006.

[27] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0005 Stakeholders Meeting”.

[28] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0016 Boskalis meeting,” 8 Oct 2021.

[29] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0007 NEDA Region3 Meeting,” 13 Oct 2021.

[30] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0008 DENR Meeting,” 20 Oct 2021.

[31] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0010 ABBP Meeting,” 21 Oct 2021.

[32] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0009 DPWH Meeting,” 26 Oct 2021.

[33] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0011 DENR Region 3,” 4 Nov 2021.

[34] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0013 DPWH Region 3,” 5 Nov 2021.

[35] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0014 San Miguel Corp,” 8 Nov 2021.

[36] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0015 BFAR Meeting,” 10 Nov 2021.

[37] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0019 NEDA Minutes of Meeting,” 12 January 2022.

[38] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0021 DENR Minutes of Meeting,” 14 January 2022.

[39] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0022 BFAR R3 Minutes of Meeting,” 25 January 2022.

[40] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0027 Minutes of Meeting with DENR MGB Central Office,” 31 January 2022.

[41] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0028 Minutes of Meeting with DPWH,” 4 February 2022.

[42] Local Government Code Sec. 57; R.A. 7160.

[43] “Zoning Plan, Local Investment Plan”.

[44] It contains the long-term vision of the province, and identifies development goals, strategies, objectives/targets and corresponding PPAs which serve as primary inputs to provincial investment programming and subsequent budgeting and plan implementation..

[45] RA 11201; name now changed to Department of Human Settlements and Urban Development; R.A. 7279; E.O. 648 & 72.

[46] “HLURB MC 19-02,” 2019.

[47] Supreme Court decision on G.R. No. 133250; July 9, 2002; Commonwealth Acct 141, Sec. 66, July 9, 2002.

[48] Fisheries Code of 1998.

[49] CA 141, Sec 66.

[50] PD 857, Dec. 23, 1975.

[51] Executive Orders Nos. 525 & 654.

[52] Disaster Risk Reduction Management Act of 2010 (R.A. 10121).

[53] Philippine Tourism Code.

[54] N. E. a. D. Authority, “Manila Bay Sustainable Development Masterplan: Annex 2 Insitutional Set-up and capacity”.

[55] Presidential Decree No. 1586. The Office of the President on its own and/or upon recommendation by the National Environmental Protection Council can declare certain areas as environmentally critical and , among others, can institute measures administered.

[56] M. Palace, “Administrative Order No. 16,” 2019.

[57] P. O. T. PHILIPPINES, “EXECUTIVE ORDER NO. 533 ADOPTING INTEGRATED COASTAL MANAGEMENT AS A NATIONAL STRATEGY,” 2014.

[58] D. o. t. I. a. L. Government, “Joint Memorandum 2017-3 Policy guidelines and procedures in the implementation of the FY 2017 Local Grovernment support fund-assistance to disadvantaged municipalities (LGSF-ADM) program,” 2017.

[59] International Union for Conservation of Nature (IUCN), “IUCN Global Standard for Nature-based Solutions,” [Online]. Available: https://www.iucn.org/theme/ecosystem-management/our-work/iucn-global-standard-nature-based-solutions.

[60] A. (. v. '. Veld, “Potential Measures to reduce Fluvial and Tidal Floods in the Pampange Delta,” 2015.

[61] P. C. SHELLFISH, “OYSTER FARMING OVERVIEW,” [Online]. Available: http://www.penncoveshellfish.com/oyster-farming-1.

[62] FAO Fisheries and Aquaculture Department, “Molluscan Shellfish farming,” [Online]. Available: http://en.aquaculture.ifremer.fr/World-statistics/Molluscan-Shellfish-farming.

[63] Collins Dictionary, “Definition of 'delta',” [Online]. Available: https://www.collinsdictionary.com/dictionary/english/delta.

[64] D. R. V. M.-D. P. Z. M. T. E. P. K. M. M. N. A. O. J. P. B. R. N. W. (. H.-O. Pörtner, “Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate,” IPCC, 2019.

[65] IPCC, “Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities,” 2021.

[66] Paalvast, “Application of string and rope structures, pole and pontoon hulas, to increase productivity and biodiversity in man-made hardsubstrate aquatic environments.,” Caen, 2015.

[67] Rijkswaterstaat (Dutch national water authority), “Maatregelen rivierengebied (Measures for river area),” [Online]. Available: https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/ruimte-voor-de-rivieren/maatregelen-rivierengebied. [Accessed 9 12 2021].

[68] Q. N. Vinh. [Online]. Available: https://www.pexels.com/nl-nl/foto/bruine-blokhuizen-in-het-midden-van-de-zee-3232577/. [Accessed 14 12 2021].

[69] EcoShape, “Restoring tidal dynamics,” [Online]. Available: https://www.ecoshape.org/en/concepts/restoring-tidal-dynamics/. [Accessed 14 12 2021].

[70] Rijkswaterstaat (Dutch water authority), “Maatregelen rivierengebied (Measures river area),” [Online]. Available: https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/ruimte-voor-de-rivieren/maatregelen-rivierengebied. [Accessed 14 12 2021].

[71] Local Government Code.

[72] E. S. d. Dios, “Discussion Paper No. 0806 Institutional Constraints on Philippine Growth,” 2008.

[73] N. E. a. D. Authority, “Manila Bay Sustainable Development Masterplan: Annex 2 Institutional setup and capacity building report”.

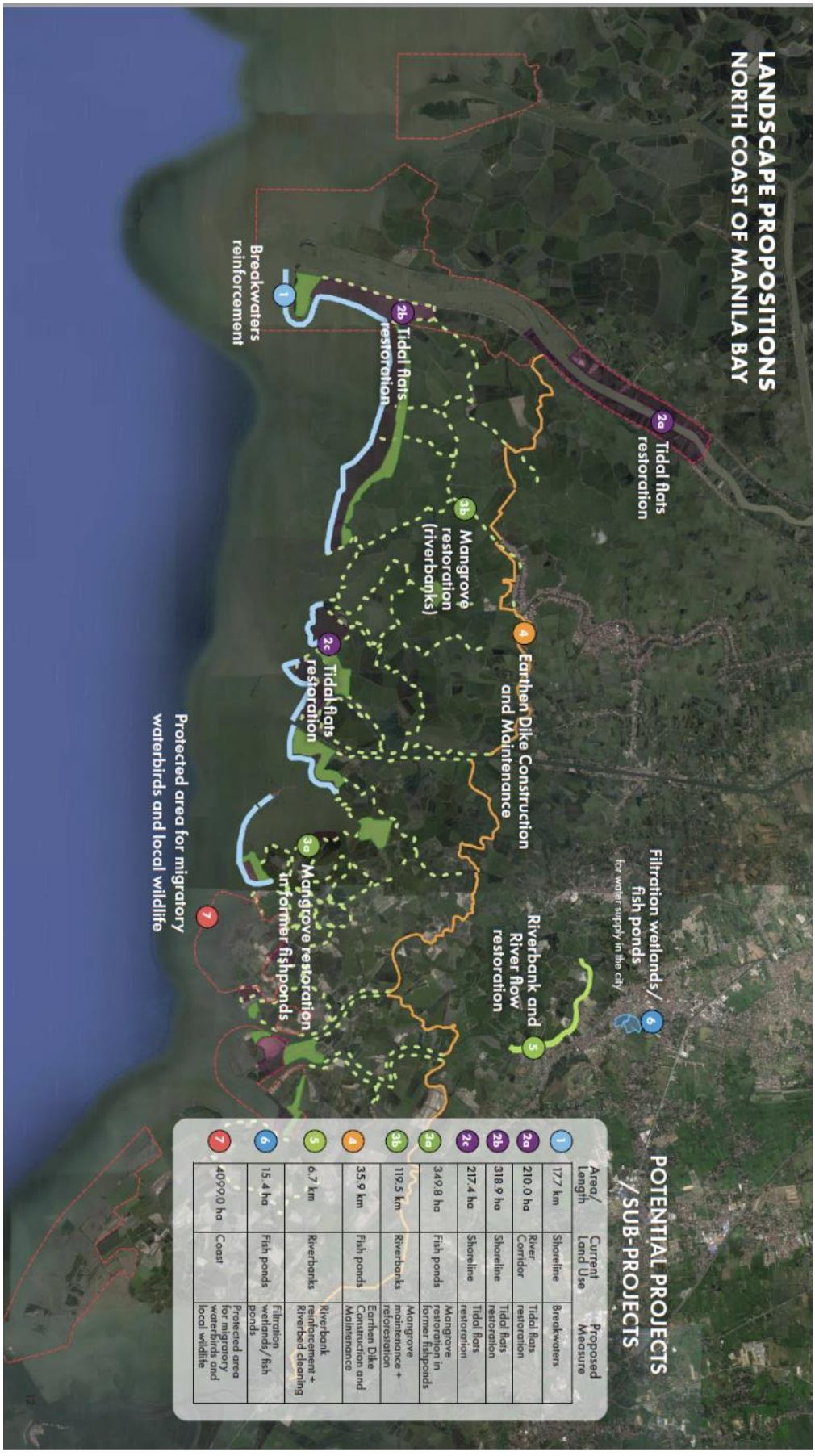
[74] Royal HaskoningDHV, “NMBFPS-RHD-PL-ZZ-MI-0025 Fishermen and Fishpond operator Minutes of Meeting,” 21 January 2022.

[75] NMBFPS-RHD-PL-ZZ-MI-0026 ABB-BP Minutes of Meeting, “NMBFPS-RHD-PL-ZZ-MI-0026 ABB-BP Minutes of Meeting,” 21 January 2022.

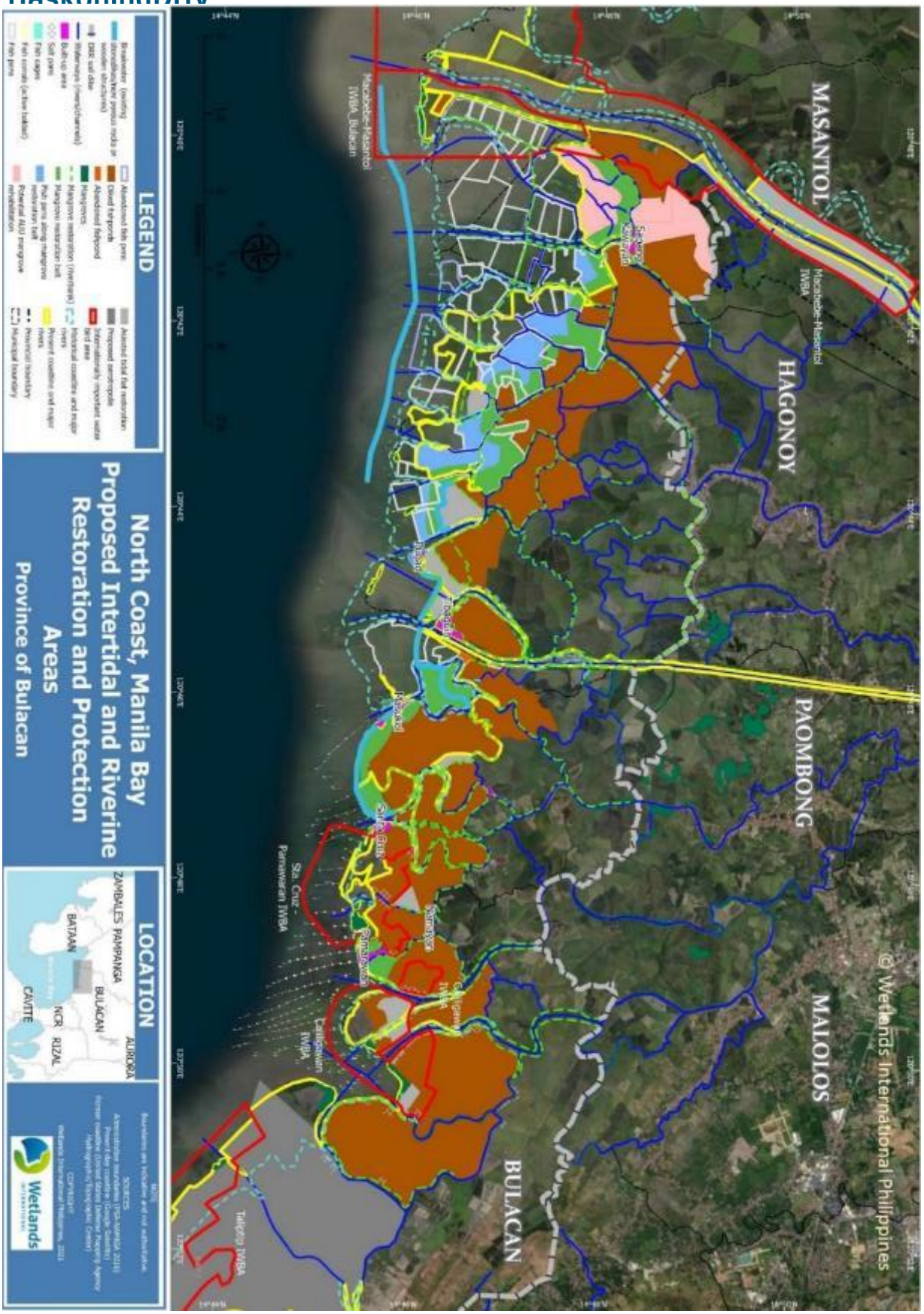
Appendix 1

Appendix 1 Landscape proposition (Wetlands)

1. Landscape proposition Building with Nature Asia
2. Landscape proposition Wetlands international Philippines



	Area/ Length	Current Land Use	Proposed Measure
1	1.7.7 km	Shoreline	Breakwaters
2a	210.0 ha	River Corridor	Tidal flats restoration
2b	318.9 ha	Shoreline	Tidal flats restoration
2c	217.4 ha	Shoreline	Tidal flats restoration
3a	349.8 ha	Fish ponds	Mangrove restoration in former fishponds
3b	119.5 km	Riverbanks	Mangrove maintenance + reforestation
4	35.9 km	Fish ponds	Earthen Dike Construction and Maintenance
5	6.7 km	Riverbanks	Riverbank reinforcement + Riverbed cleaning
6	15.4 ha	Fish ponds	Filtration wetlands / fish ponds
7	4099.0 ha	Coast	Protected area for migratory waterbirds and local wildlife


LEGEND
North Coast, Manila Bay
Proposed Intertidal and Riverine
Restoration and Protection
Areas
Province of Bulacan
LOCATION
MASANTOL
HAGONOY
PAOMBONG
MALOLOS
BULACAN
Macabebe-Masantol
IWBA
Sta. Cruz-
Pamarawan IWBA
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IWBA
Tabangao IWBA
© Wetlands International Philippines
ZAMBALES
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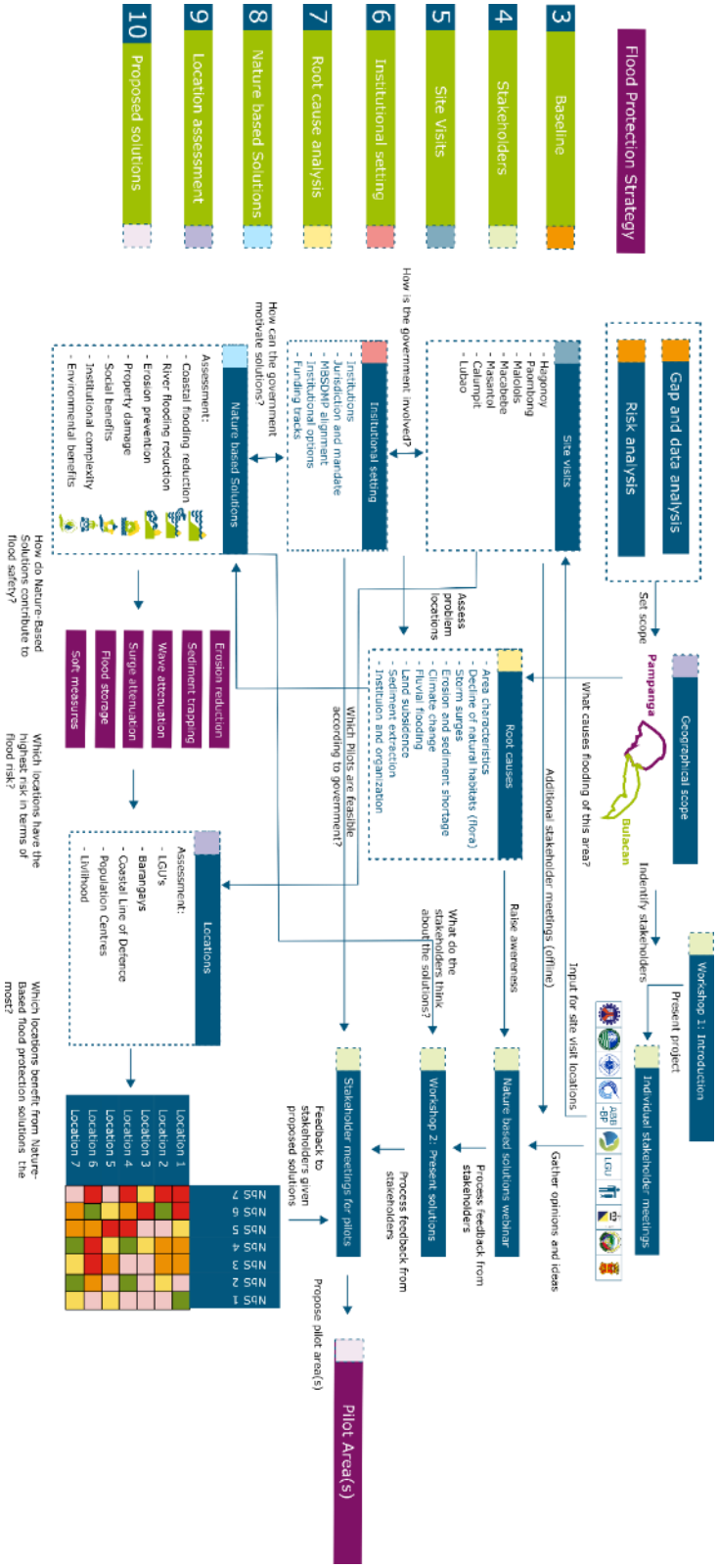
Appendix 2

Appendix 2 Strategy guide


Flood Protection Strategy
3 Baseline
4 Stakeholders
5 Site Visits
6 Institutional setting
7 Root cause analysis
8 Nature based Solutions
9 Location assessment
10 Proposed solutions
Gap and data analysis
Risk analysis
Set scope
Geographical scope
Pampanga
Bulacan
Workshop 1: Introduction
Present project
Individual stakeholder meetings
Identify stakeholders
Site visits
- Hagonoy
- Paombong
- Malolos
- Macabebe
- Masantol
- Calumpit
- Lubao
How is the government involved?
Institutional setting
- Institutions
- Jurisdiction and mandate
- MBSDMP alignment
- Institutional options
- Funding tracks
How can the government motivate solutions?
Nature based Solutions
Assessment:
- Coastal flooding reduction
- River flooding reduction
- Erosion prevention
- Property damage
- Social benefits
- Institutional complexity
- Environmental benefits
Assess problem locations
Root causes
- Area characteristics
- Decline of natural habitats (flora)
- Storm surges
- Erosion and sediment shortage
- Climate change
- Fluvial flooding
- Land subsidence
- Sediment extraction
- Institution and organization
What causes flooding of this area?
Additional stakeholder meetings (offline)
Input for site visit locations
Which Pilots are feasible according to government?
Raise awareness
Nature based solutions webinar
Process feedback from stakeholders
Gather opinions and ideas
What do the stakeholders think about the solutions?
Workshop 2: Present solutions
Process feedback from stakeholders
Stakeholder meetings for pilots
Feedback to stakeholders given proposed solutions
Propose pilot area(s)
Pilot Area(s)
How do Nature Based Solutions contribute to flood safety?
Erosion reduction
Sediment trapping
Wave attenuation
Surge attenuation
Flood storage
Soft measures
Which locations have the highest risk in terms of flood risk?
Locations
Assessment:
- LGU's
- Barangays
- Coastal Line of Defence
- Population Centres
- Livlihood
Which locations benefit from Nature-Based flood protection solutions the most?
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6
Location 7
NBS 1
NBS 2
NBS 3
NBS 4
NBS 5
NBS 6
NBS 7

Appendix 3

Appendix 3 Site visit data

A.3.1 Site Visit Itinerary

The following tables present the itinerary of the site visits held from 09 November to 01 December 2022.

Table A-3.1 – Hagonoy Site Visit Itinerary

Date: 09 Novemeber 2022			
Place: Hagonoy, Bulacan			
Time	**Place**	**Activity**	**Person In Charge**
8:00am	Vice Mayors office	Meeting with Vice Mayor Cruz Introducing the team and discuss the strategy	Vice Mayor Cruz
8:00am	Mayors office	Courtesy call at Mayor's office	Jeff, CJ, Karen, Rose
9:00am	Meeting Hall	Conduct Foucus Group Discussion (FGD) with 10 fishermen group in Brgy. Tibagin	Rose, CJ, Karen and Jeff
9:00am	Site	Drone flying video and picture taking in Hagonoy and Calumpit	Karl
12:00pm	Lunch		
1:00pm	Meeting Hall	Conduct FGD with 5 fishermen group and 15 aqua culture group in Brgy San Pablo, Sagrada and San Sebastian	Rose, CJ, Karen and Jeff
1:00pm	Site	Drone flying video and picture taking in Macabebe and Masantol	Karl and Mariane
3:00pm	Vice Mayors Office	Meeting with Vice Mayor	CJ, Jeff, Karen, Mariane and Karl

Table A-3.2 – Paombong Site Visit Itinerary

Date: 11 Novemeber 2022			
Place: Paombong, Bulacan			
Time	**Place**	**Activity**	**Person In Charge**
8:00am	Paombong Municipality Hall	Meeting wirh MENRO	
8:30am	Site	Picture Taking along coastal line of Paombong and interview at Brgy Sta. Cruz	Jeff, CJ, Karen
12:00pm	Lunch		
1:30pm	Meeting Hall	Meeting with 15 fishermen and 15 aquatic culture (2 groups)	Jeff, CJ, Karen
3:30pm	Meeting Hall	Meeting with MENRO	Jeff, CJ, Karen

Table A-3.3 – Malolos Site Visit Itinerary

Date: 15 Novemeber 2022			
Place: City of Malolos, Bulacan			
Time	**Place**	**Activity**	**Person In Charge**
8:00am	Malolos City Hall	Meeting Place going to coastal line	Arne, Jeff, Karen, CJ, Sheen
8:30am	Site	Picture Taking along coastal line of Malolos and interview at Brgy Pamawaran	Arne, Jeff, Karen, CJ, Sheen
12:00pm	Lunch		
1:00pm	Mayors Office	Courtesy Call at Mayors office	Jeff, Sheen, Rose
1:30pm	Meeting Hall	Meeting with 15 fishermen and 15 aquaculture	Ms. Rose, Jeff, Sheen
3:30pm	Meeting Hall	Arrival from Brgy. Pamawaran	CJ, Karen, Arne

Table A-3.4 – Macabebe and Masantol Site Visit Itinerary

Date: 16 Novemeber 2022			
Place: Macabebe and Masantol, Pampanga			
Time	**Place**	**Activity**	**Person In Charge**
9:00am	Masantol Municipal Hall	Meeting at Menro's Office	Mariane, Sheen, Jeff, Karl and Karen
9:15am	Meeting Hall	Focus group meeting with fishermen	Jeff and Mariane
9:15am	Site	Drone Flying and picture taking	Sheen and Karl
10:30pm	Meeting Hall	Interview with the community	Karen
12:00pm	Lunch		
1:00pm	Macabebe Municipal Hall	Meeting with Administrative Office	Jeff and Karen
1:15pm	Meeting Hall	Focus group meeting with fishermen	Jeff and Karen
1:15pm	Site	Drone Flying and picture taking	Sheen, Mariane and Karl
3:30pm	Meeting Hall	Interview to community	Karen and JP

Table A-3.5 Calumpit Site Visit Itinerary

Date: 17 Novemeber 2022			
Place: Calumpit, Bulacan			
Time	**Place**	**Activity**	**Person In Charge**
8:00am	Calumpit Minicipal Hall	Meeting at MEO	Jeff, Karen, Sheen, Dr. Rene and Mariane
8:30am	Site	Picture Taking along Pampanga River and Interview with community	Jeff, Sheen, Dr. Rene
8:30am	Brgy Sapang Bayan and Brgy San Miguel	Community interview	Karen and Mariane
12:00pm	Lunch		
1:30pm	Meeting Hall	Meeting with 15 fishermen	Arne, Jeff, Karen, Sheen, Dr. Rene
3:30pm	Mayors Office	Courtesy Call at Mayor's office	Karen, Jeff, Mariane, Dr. Rene and Sheen

Table A-3.6 – Lubao Site Visit Itinerary

Date: 01 December 2022			
Place: Lubao, Pampanga			
Time	**Place**	**Activity**	**Person In Charge**
8:00am	Lubao Municipal Hall	Meeting place with LGU staff and introducing the team	Jeff, JP, Mariane, Karl, Sheen, Atty. Chris
9:00am	Site Visit	Conduct Site Visit by taking pictures, drone flying, and interviewing with the community nearby coast of Lubao (Barangay Bancal Pugad) Site visits along the coastal: (Arne, JP and Sheen) 1. lower lubao from Orani next to delta mouth 2. Drone Flying in Bancal Pugad (Karl) 3. Interview communities is Bancal Pugad (Mariane)	JP, Mariane, Sheen, Karl
10:00am	Barangay Hall	Focus Group Discussion with 15 fishermen in Barangay Bancal Pugad	Jeff and Atty. Chris
12:00pm	Lunch		
1:00pm	Site Visit	Conduct Site Visit by taking pictures, drone flying Site visits along the coastal: (JP, Arne, Sheen and Karl) 1. upper Lubao 20 km upstream. Other boat will go back to Lubao Municipal Hall (Mariane and Jeff)	JP, Mariane, Sheen, Karl, Jeff and Atty. Chris
2:00pm	Mayors Office	Meeting with MENRO,MEO and Admin	Jeff, Marianne and Atty. Chris
3:00pm	Site Visit	Arrival from Site Visit	JP, Karl, Sheen

A.3.2 Logbook

A.3.2.1 Hagonoy, Bulacan - 9 November

The team commenced the first site visit in the municipality of Hagonoy with a courtesy call with the Mayor and a brief meeting with Hagonoy's local officials. The team explained the rationale of the project and the site visit itinerary with the Mayor, Vice Mayor, and other representatives of Hagonoy LGU.

Figure A-3.1 – Courtesy call with Mayor Raulito T. Manlapaz

The second part of the day consisted out of a site visit in Barangay Tibaguin which lies approximately 5 km south of Hagonoy town proper and is adjacent to the coastline. At the time of the site visits high tides where occurring during night, traces of this were still to be seen on the morning after, see Figure A-3.2.

Figure A-3.2: Natural high tide at Barangay Tabguin

During the site visit focus group discussions with stakeholders where conduction composing of approximately 15 fisherfolk and 15 aquaculture farmers. This was repeated for 4 Barangays; Tibaguin, Pugad, Sagrada, and San Pablo. After presenting the options for Nature-based Solutions as flood protection measure there was a constructive dialogue held one of the main points from the stakeholders were the community preferred mangrove belt and fishpond for livelihood and they are willing to cooperate to protect the flood protection strategy. Due to the high attendance the team was successful in raising awareness about the Strategy and Nature-based Solutions. In parallel with the focus group discussion various (random) people were interviewed in each Barangay which resulted in the household survey overview discussed in the main report. Another part of the team did a survey type of site visit in which they collected photographic and drone (video) material which can be used to gather a better understanding of the area for people who have not been on the site visit.

Figure A-3.3.Hagonoy Interview with the community

Figure A-3.4 – Focus Group Discussion in Sagrada and San Pablo

Figure A-3.5 – Drone shots in Tibaguin (upper left) and Pugad (upper right). A view at fishponds (lower left) and Manila Bay (lower right)

A.3.2.2 Paombong, Bulacan - 11 November

The team commenced the site visit in the municipality of Paombong. The team had a coordination meeting with the Paombong Municipal Environment and Natural Resources Office (MENRO) representative to explain the rational of the project and site visit. MENRO mentioned for planning the 80 hectares mangrove in masukol dike in coordination with San Miguel Corporation.

The second part of the day consisted out of site visit in Barangay Sta. Cruz which lies approximately 7 kilometers south of Paombong town proper and is adjacent coastline. The team together with MENRO representative had a courtesy call with Barangay Captain.

During our site visit the focus group discussion with ten (10) random residents were interviewed which resulted in household survey.The survey guide questions about their coastal hazard experience, their response to it, and their perception of nature-based solutions.

Figure A-3.6 – Coordination meeting with MENRO

In parallel field survey conducted simultaneously did the survey type of site which they collected the photographic and drone video material which can be used to gather the data. Included are the photos of built structures such as Masukol & Sta. Cruz Dike, oyster farm as their source of livelihood, experienced low tide during our ocular inspections.

Figure A-3.7 – Shallow areas at Manila Bay (left) and existing mangrove (right)

The focus group discussion with the stakeholders composed of 20 fishers and aquaculture farmers. The team presented had a forum with them about Nature-based Solutions. The team presented the different

NbS for flood protection. After the presentation there was a constructive dialogue held, one of the main points was the community agreed to the use of NbS. They will setup a cooperative to protect the flood protection strategy. Due to high attendance the team was successful in raising awareness about the strategy and Nature-based Solutions.

Figure A-3.8 – Focus Group Discussion with fishers and aquaculture

Figure A-3.9 - Oyster farm for livelihood and Sta. Cruz dike and existing mangrove (above). View at Brgy. Sta. Cruz and existing mudflats and mangroves (below)

A.3.2.3 City of Malolos, Bulacan - 15 November

The team commenced the site visit in the City of Malolos.The team had a coordination meeting with the Office of the mayor's representative to discuss about the planned activity. Later that day, there was a

courtesy call with the Mayor, the team discussed the project and its benefits. Mayor Gatchalian is also an advocate of Nature-based Solutions; a future mangrove planting project in Manila bay with 50,000 mangrove species will start by December 2021.

Figure A-3.10 - Courtesy call to Mayor Gilbert Gatchalian

The second part of the day consisted out of a site visit in Barangay Pmarawan. Prior to the vistit, the team extended the courtesy call to the Barangay officials present in Pamarawan Barangay Hall. The team coordinated the purpose of the site visit, interview the community, site inspection in Manila Bay, and drone flying. Using the map given by the team (see Figure A-3.11), the site team decided to take route 'B' for site inspection.

Figure A-3.11 - Courtesy Call to Barangay Captain in Pamawaran (left) and Ocular route (right)

As the team followed Route B, it was observed that the area is rich of ecological features such as saltpans, shallow fishponds, tidal flats, mangroves, migratory species, and small-scale fisheries and shellfish production in the area (see Figure A-3.12).

Figure A-3.12 - Existing mangroves (left) and small-scale shellfish production (right)

During the site visit, a focus group discussion with stakeholders composed of 30 fisherfolks from various barangays in Malolos was also conducted. The team presented the concept of Nature-based Solutions for flood protection, and received a positive feedback. They are very cooperative in giving information, sharing their experience about flooding, and providing insights about NbS.

Figure A-3.13 - Focus Group Discussion with Fisherfolks

In parallel with the focus group discussion, various (random) people were interviewed in each Barangay which made up the household survey. Another part of the team did a survey type of site visit in which they collected photographic and drone (video) material which can be used to gather a better understanding of the area for people who have not been on the site visit.

Figure A-3.14. Interview in Barangay Pamarawan

Figure A-3.15 – Drone shot at Manila Bay (upper left), Mangroves and Nipa (lower and upper right), and oyster farm for livelihood (lower left)

A.3.2.4 Masantol, Pampanga - 16 November

The team had a coordination meeting with a representative from the Municipal Environmental and Natural Resources Office (MENRO) in Masantol LGU. The team discussed the purpose of visits, and these are site inspection and conducting focus group discussion.

Together with MENRO, the site team navigated the bodies of water traversing of the municipalities of Masantol and Macabebe, Pampanga. The site team took pictures and videos using drones along with the Bebe – San Esteban cut-off channel and Pampanga river until it reached the southern portion of Macabebe downstream.

Figure A-3.16 – Fishponds in Sapang Kawayan (left)Pampanga River Delta (right)

The site team had random residents along the riverside at Barangay Palimpe and Sapang Kawayan who were interviewed and shared their flooding experience and response using our survey questions. The team interviewed around ten residences, and they were very cooperative in sharing their thoughts during the interview.

Figure A-3.17 - Community Interview in Masantol, Pampanga

In a parallel activity, the Focus Group team conducted the forum discussion with stakeholders composed of 15 fisherfolks in Masantol. They are very participative in our discussions by sharing their inputs related to the Strategy when presented and giving information about their experience during flooding. They expressed their issue about natural high tide from Manila bay. They are hoping that their town will be the pilot location.

Figure A-3.18 - Focus Group Discussion with Fishermen in Masantol

Figure A-3.19 - Drone footage along with Pampanga River (upper and lower left) and fishpond (upper and lower right)

A.3.2.5 Macabebe, Pampanga - 16 November

The team together with Wetlands International Philippines commenced the site visit in the municipality of Macabebe with the courtesy call with municipality Councilor for a brief meeting. The team explained the rational of project and site visit itinerary with them. The Councilor is supportive to our project and hopeful that their town will be the pilot location.

During the focus group discussion with stakeholders where conduction composing of 20 fisherfoks in 3 barangays namely; Consuelo, San Esteban and Dalayap. After presenting the options for Nature-based Solutions as flood protection measure. There was a contructive dialogue help one of the main points from stakeholders was the main issue is land subsidence. They understand that our solution is to prevent flood from coastal. They are open to our concepts and willing to mainting on it. Due to high attemdance the team was successful in raising awareness about the strategy and Nature-based Solutions.

Figure A-3.20 - Focus Group Discussion with Fishermen in Macabebe

In parallel with the focus discussion, the team did a survey type of visit in which they collected photos and drone video material. These can be used to gather and better understanding for the area especially to our team who have been on the site. They also had a random people were interviewed which resulted in household survey overview.

Figure A.3-21 - Drone footage along Pampanga River with existing Mangrove and fish pond in Macabebe, Pampanga

A.3.2.6 Calumpit, Bulacan - 17 November

The together with Wetlands International Philippines commenced the site visit in the municipality of Calumpit with a courtesy call with Mayor and other local officials. The team explained the rationale of the project and the site visit itinerary with them. The Mayor informed us the dredging project in Pampanga River. This was already forecasted with DPWH for year 2022.

Figure A-3.22 - Courtesy call with Mayor Jessie De Jesus

During the site visit, approximately 15 random people were interviewed in Barangay Meysulao, San Miguel and Sapang Bayan which resulted in the household survey overview. At that tme of site visits there are still flooded areas in the barangays. According to the residence the flood will subside in 30 estimated days. Another part of the team did the survey type of the sit e visit which they collected photos materials. These can be used as a data gathering for the team especially for those who have been in the site.

The team had a Focus Group Discussion with Stakeholders composed of 30 fishers and farmers with the help of Calumpit LGU representatives. After presenting the options for Nature-based Solutions as flood protection measure there was a constructive dialogue held one of the main points was the community want to present us a solutions in flooding issu and they have apprehension for implementing the project. Due to the high attendance the team was successful in raising awareness about the strategy and Nature-based Solutions.

Figure A-3.23 - Focus Group Discussion with Fishermen and Farmers

Figure A-3.24 – Picture of the dike (upper and lower left) and mangroves (upper and lower right)

A.3.2.7 Lubao, Pampanga - 01 December

The team together with Wetlands International Phlippines commenced the last site visit in the municipality of Lubao. The team had a coordination meeting with LGU officials to explained the rationale of the project and site visit itinerary. After prensenting potential NbS for flood protection, the Municipal Engineering Office (MEO) still consider structural solutions and a combination of structures and Nature-based Solutions.

Figure A-3.25 - Discussion with MENRO, MEO, and Admin

The 2nd part of the day consisted out of a site visit in Barangay Bancal Pugad which lies approximately 9 kilometers south of Lubao town proper and its adjacent to the coastline. We had courtesy call with Barangay Captain to assist us during site visit.

During our site visit focus group discussion with stakeholders were conducted composed of 10 fisherfolks in Barangay Bancal Pugad. After presenting the options for Nature-based Solutions as flood protection measure there was a constructive dialogue held one of the main points from the stakeholders was to setup an organization or association to maintian the project. Due to the good attendance, the team was successful in raising awareness about the strategy and Nature-based Solutions.

Figure A-3.26 - Focus Group Discussion with Fishermen in Lubao, Pampanga

In parallel with the focus group discussion, various (random) people were interviewed in Barangay to share their experience during flooding events which resulted in the household survey overview. Another part of the team did a survey type of site visit in they collected pictures such as existing mangroves trees, and fishponds, and aerial drone shots and videos. These materials can be used to gather a better understanding of the area for the team especially for those who have not been on the site.

Figure A-3.27 - Drone shots in Lubao, Pampanga

Figure A-3.28 – Picture of mangrove (upper left and right), and fish ponds (lower left and right)

A.3.2.8 Hagonoy, Bulacan - 21 January

The North Manila Bay Flood Protection Strategy Team together with Netherlands Embassy presented the Strategy in proposed pilot location in municipality of Hagonoy. The team explained the proposed Nature-based Solutions in pilot locations namely: Hagonoy, Masantol and Macabebe.

Present in the workshop are 15 fishermen and 15 fishpond operators from the three municipalities. After presenting the goals, flood protections measures, and possible pilot, a constructive dialogue held and the main points are:

- Agreed to implement the Nature-based Solution for flood protection measures.
- Educate the opportunity for biodiversity livelihood for the community.
- Educate about proposed solutions in the pilot locations.
- Emphasis of lack of planning in DPWH dredging activities in Pampanga River.

Figure A-3.29 – Discussion with fisermen and fishpond operators (left) and Group picture (right)

The second part of the day is focus group discussion with LGU representatives from the possible pilot locations. The main points of discussion are:

- Funding will be allocate from DILG.
- 20 – 30 million project can be allocated in LGU level.
- Municipalities in pilot locations are commited to implement even in small projects.
- Emphasis of lack of planning in DPWH dredging activities in Pampanga River.
- Confirmation of the exisitng structures based on QGIS.

Figure A-3.30 – Group picture with LGU representative in propoosed pilot locations

Due to the good attendance, the team was successful in presenting the solutions to the fishermen and fishpond operators, enhancing awareness of the different kinds of Nature-based Solutions in proposed pilot locations, and maintaining a healthy dialogue and collaboration with the LGU representatives.

Focus Group Discussion Results

Table A-3.7 - Hagonoy Focus Group Discussion Results

QUESTION / MUNICIPALITY / BARANGAY	Brgy. Pugad and Tibaguin, Hagonoy	Brgy. Sagrada, Hagonoy	Brgy. San Pablo, Hagonoy
1. Distance of Houses from Coastline	Beside coastline	Around 15 km from Ancing	Beside coastline; Around 3-4km
2. Natural Resources Used in Daily Life	Livelihood: Dried Fish Fishing	Livelihood: Fishery, fishponds converted from former rice fields	Livelihood: Fishing
3. Where Floodwaters Come From	Waves due to monsoon, Flooding from Manila Bay	High tide (4.6m recently experienced), Recent reclamation projects, River flooding, Release of waters from dams	Solid wastes, Shallow riverbed, Lahar, Narrowing of river, Dike causes flooding in roads
4. Warning Signs of Imminent Flooding	Whistle of the wind, Sudden influx of fishes, Barangay system, News	No warning from LGU, Mass media: TV, radio, etc.	High tide accumulation (from knee to chest level), Dam, For far from the coast: Bukung Bukung, Sudden influx of fishes, TV/FB
5. Hours Between Receiving Warning and Flooding	Minimum: 30 mins Maximum 3 hours	No lag time	1 day before from Calumpit - 1 day more Paghupa: November 2020 - 3 to 7 days (Heavy Rains + Dams) Kabayanan - waist to chest level
6. Activities Preparing for Flooding Threat	Evacuate to Hagonoy, Evacuate to neighbor, Secure roofs	Every household will have their own strategies against flooding	Mooring of boats in place, prepare food/medicine, raise belongings to higher elevation
7. Frequency of Flooding	High Tide (everyday - midnight: November to March; every morning - May to August)	Note: 6 hours peak flooding but it also takes 6 hours to clear floodwater	High Tide - Monthly; Flooding from upstream occurs during typhoon season
8. Depth of Floodwaters	Knee level: High tide, Shoulder level: typhoons	Waist level: Typhoon Pedring	Lowest: waist level Highest: chest level

		Hagonoy was flooded for 13 days during typhoon Pedring	
9. Causes of Flooding	Improper waste disposal, nearby reclamation projects, lack of mangroves	Water from dam & high tide from sea Flood from upstream	Rain, High tide, calendar (Note: In 2021, high tide was experienced almost every month)
10. Community/Association Initiatives	No Active Association or Cooperative	Fish processing facility (tinapa, tuyo, etc.) Project of mangrove development from World Bank (planned project for now)	Main Organization: Samahan ng mangigisda ng Hagonoy.
11. Provincial/Municipal Govt Initiatives	Mangrove planting, BSU/BFAR/Province	Dike reinforcement in Pugad & Sta. Elena Dike in Paombong is the most reinforced Delta improvement Rice fields converted to fishponds	Cong. Alvarado implemented the dike construction.
12. Expectations from Nature-Based Solutions	Improvement in livelihood, reduce damage to properties, protection from wave impact, "back to normal" similar to 1970-2000s (lesser flooding)	If NMBFPS is implemented: Control Flooding, More fishes which can promote livelihood, Lower wave heights, Control high tide events, Improvement in aquaculture developments	Improvement in health and livelihood
13. Advantages of Nature-Based Solutions	Combined mangrove and fishpond, increase in natural sea creatures, prevent flooding, improve tourist spots	Double Dike System, Provide support for flooding and wave attack on both sides of water bodies, improve marine life and habitat of fishes, lesser damage to household during typhoons, Possible species (Mangrove, sasa, palapat, api-api)	Mangroves already used & proven which will result in more fish and income for fisherfolks
14. Disadvantages of Nature-Based Solutions	Mangroves maintenance, Mangroves caretaking responsibility	Double Dike System Maintenance Implementation/Coordination with LGUs Main issues for mangrove: Maintenance & Funding	Nothing

		Mangrove planting but no maintenance No maintenance activities or inspection for the mangrove planting	
15. Concerns on Implementation	Effects of dike on livelihood once constructed, reviving the beauty of natural resources	Effect to neighbouring private fisheries, Pilapil when flood protection strategies are deployed, More opportunities for "business making", others might take advantage More improvement in drainage projects since an elevated road has a bad set of drainage which requires more studies	Fishing area may be limited Problems in municipal waters are experienced Cong. Alvarado implemented the dike construction but it was not a solution for the flooding occurrences. In fact, the locals even mentioned that this became the cause of flooding.

Table A-3.8 - Paombong Focus Group Discussion Results

QUESTION / MUNICIPALITY / BARANGAY	PAOMBONG
1. Distance of Houses from Coastline	Around 3-4.5km
2. Natural Resources Used in Daily Life	Livelihood: Aquaculture Tuba gathering (Nipa vinegar) Vegetables & Rice fields
3. Where Floodwaters Come From	High tide (Riverside): up to 4.9m; High tide (Barrio): up to 1m Release of waters from Dam Typhoons Shallow riverbed
4. Warning Signs of Imminent Flooding	LGU National TV FB
5. Hours Between Receiving Warning and Flooding	LGU via social media high tide, 2 days before usually
6. Activities Preparing for Flooding Threat	Mooring of boats in place raise belongings to higher elevation
7. Frequency of Flooding	During typhoon During high tides
8. Depth of Floodwaters	Coastal: waist level Barrio: knee level
9. Causes of Flooding	Conversion of fishpond to residential Conversion of farmland to fishpond Destroyed/Damaged pilapil Low seabed & river bed Drainage system clogged & plastic waste overflow coming from rice fields release of dam waters Land subsidence Waste management in creek and river
10. Community/Association Initiatives	Drainage maintenance -> Dredging of canal (collab w/LGU) waste trap in rivers initiative of LGU (continuous waste management) Coastal areas: Coastal clean up
11. Provincial/Municipal Govt Initiatives	Collab w/ LGU -> Clean up drive Sanitary landfill drive Converted ecopark open to public Coastal clean-up drives for area near shoreline
12. Expectations from Nature-Based Solutions	Planting of mangroves decomposing of garbage recycling
13. Advantages of Nature-Based Solutions	Improvement in marine life Use of "bakawan" to control population
14. Disadvantages of Nature-Based Solutions	Nothing

15. Concerns on Implementation	Discipline & maintenance in planting mangroves Budget waste based on previous project

Table A-3.9 - Malolos Focus Group Discussion Results

QUESTION / MUNICIPALITY / BARANGAY	MALOLOS
1. Distance of Houses from Coastline	Beside coastline (Pamarawan) Beside coastline (Caliligawan) Beside coastline (Meycauayan) Beside coastline (Masi Ho) Beside coastline (Babatnin) 7 km (Calero) Inland (Bagna)
2. Natural Resources Used in Daily Life	Livelihood: Fishing Food: Vegetables Livelihood: Goat rearing Livelihood: Fishpond/Aquaculture Livelihood: Oyster Farming
3. Where Floodwaters Come From	Tidal flooding due to monsoon Flooding from upstream areas Typhoons
4. Warning Signs of Imminent Flooding	Calendar: tide measurements TV news MDRRMC: Text messages Social media Monsoon 'wind' & waves
5. Hours Between Receiving Warning and Flooding	Calendar 1 day from DRRM 1 day from TV news
6. Activities Preparing for Flooding Threat	Pilapil embankment Raise belongings to higher places Tie boats Stay inside house
7. Frequency of Flooding	Weekly: high tide Bimonthly During typhoon (Calero)
8. Depth of Floodwaters	Knee level: Tidal flooding (Pamarawan) Leg level: Typhoon Ulysses (Calero) Knee level: Tidal Flooding (Pamarawan)
9. Causes of Flooding	Lack of drainage system (Calero) Inadequate drainage system (Poblacion) Solid wastes Coastal informal settlers Reclamation of MOA (Bagna) Land subsidence: due to volcano eruption (Malolos) Subdivision development (river dredging & mountains) Ineffective implementation of project plans lacks coordination with Dam operators to LGU
10. Community/Association Initiatives	Samahan ng Mangingisda (Pamarawan) Samahan ng namamanti (Pamarawan)

	Samahan ng mga Mangingisda (Calero) Samahan ng mga palaisdaan (Masile) Samahan ng mangingisda (Masile) FARM-C: Manages mangroves Samahan Bigkis Tungo sa Kaunlaran (Caliligawan) Samahan ng Kalipunan ng Mangingisda sa Malolos
11. Provincial/Municipal Govt Intitiatives	Proper coordination of LGU to BFAR technology transfer funding support from BFAR Free nets, motor, and boats livelihood (sari-sari store) trainings about livelihood
12. Expectations from Nature-Based Solutions	Long term solution Long term management of mangroves
13. Advantages of Nature-Based Solutions	Dike: Protection in Flooding (Pamarawan)
14. Disadvantages of Nature-Based Solutions	Dike blocks influx of fishes
15. Concerns on Implementation	Risk of losing livelihood tide calendar no longer consistent with actual tide heights

Table A-3.10 - Macabebe Focus Group Discussion Results

QUESTION / MUNICIPALITY / BARANGAY	MACABEBE
1. Distance of Houses from Coastline	5km (Consuelo) 5km - 7km (San Esteban) 7km (Dalayap)
2. Natural Resources Used in Daily Life	Livelihood: Fishing Livelihood: Vegetable planting along dike
3. Where Floodwaters Come From	High Tide Encounter: Manila bay & Pampanga river Encounter: Dagupan river & Apalit river Typhoons Solid wastes
4. Warning Signs of Imminent Flooding	Cellphone warnings LGU: Megaphone announcement
5. Hours Between Receiving Warning and Flooding	2-3 days before typhoon strikes
6. Activities Preparing for Flooding Threat	secure houses raise belongings to higher places evacuate c/o LGU Fix fishnets in fishponds store food monitoring in rise of water level
7. Frequency of Flooding	High tide: 3 hours - water clearance (Consuelo & San Esteban) Typhoon: 5 hours - water clearance (Consuelo & San Esteban) High tide: 6 hours - water clearance (Dalayap) Sta. Tacasan - typhoon - 3 years
8. Depth of Floodwaters	Waist level (Barangay road) Neck Level (Sta. Tacasan - road) chest level (San Esteban)
9. Causes of Flooding	Solid waste management Inadequate drainage system Pavement elevation illegal structures like fish trap amidst river water lilies
10. Community/Association Initiatives	Mushroom & Fisherfolks (Sitio Mindanao - San Esteban) Samahan ng mga Mangingisda Cooperative (Dalayap) St. John's Fishermen & Fisherfolk (San Juan) Candelaria Bukang Liwayway (Candelaria)
11. Provincial/Municipal Govt Intitiatives	FARM-C
12. Expectations from Nature-Based Solutions	Livelihood improvement Cleansing of water bodies Better water inflow for fishponds Better fish quality (bigger size)
13. Advantages of Nature-Based Solutions	protection against waves protection against erosion protection against flooding marine life sanctuary Lifestyle improvement helps controlling pests in fishponds

	increase in fish quantity will protect fishponds
14. Disadvantages of Nature-Based Solutions	Nothing
15. Concerns on Implementation	Dredging of rivers Poultry wastes that attract pests River poisoning Stagnant water which leads to fishkill Authorities catching fishermen

Table A-3.11 Masantol Focus Group Discussion Results

QUESTION / MUNICIPALITY / BARANGAY	MASANTOL
1. Distance of Houses from Coastline	Beside coastline (Sapang Kawayan) Beside coastline (Nuige) Beside coastline (Sagrada Pamilya) Beside coastline (Bagang) Beside coastline (Balibago) Beside coastline (Alauli) Beside coastline (Malauli) Beside coastline (San Pedro Bulacus) Beside coastline (Buti) Beside coastline (San Agustin) Inland (Sta. Monica) Beside coastline (Bebe Matua) Beside coastline (Bebe Anac) Beside coastline (Sta, Cruz) Beside coastline (San Isidro)
2. Natural Resources Used in Daily Life	Livelihood: Fishing Livelihood: Agriculture Livelihood: Fishpond/Aquaculture
3. Where Floodwaters Come From	Flooding from rivers High Tide
4. Warning Signs of Imminent Flooding	MDRRMC: Text messages LGU: Siren & Radio Rain Gauge: Water Level TV news
5. Hours Between Receiving Warning and Flooding	1 hour 1-2 days from MDRRMC
6. Activities Preparing for Flooding Threat	raise belongings to higher places evacuate at Sagrada food distribution from LGU Ayuda'
7. Frequency of Flooding	High tide: everyday High tide: everyday (Sapang Kawayan) 1 week - 1 month (Bayan) Continuous flooding (Sagrada) Stangant Water for months (San Isidro)
8. Depth of Floodwaters	Chest level (Sapang Kawayan) Leg Level (San Isidro) Waist Level (San Isidro) Waist level (Bayan)
9. Causes of Flooding	Overflow from fishing zones (Sapang Kawayan) Storm Surge Flood from upstream areas Barangay outfall discharge in rivers high tide solid wastes Shallow riverbed: Mt. Pinatubo eruption sea level rise land subsidence due to groundwater extraction many deep wells

10. Community/Association Initiatives	Samahan ng Bakhawan Municipal Agri. Fish Corp Coastal Fisheries Coop. Fishermen Assoc. Samahan ng Namamalakay ng Sapang Kawayan
11. Provincial/Municipal Govt Intitiatives	Bakawan Pampanga Coastal Emergency Response (Response)
12. Expectations from Nature-Based Solutions	Increase quantity of marine products flood reduction lessen the impacts of natural disaster improve livelihood engineering intervention to low lying areas (e.g. pumping station, rain dike)
13. Advantages of Nature-Based Solutions	Mangroves are sanctuary for fishes, migratory birds Mangroves are spawning area for fishes mangroves have big advantage source of livelihood (e,.g. vinegar, nipa hut)
14. Disadvantages of Nature-Based Solutions	Mangrove do not have disadvantages Mangroves takes too long to grow People has no expertise on growing mangroves effectively
15. Concerns on Implementation	Having to relocate due to frequent flooding DPWH & DENR - cuts mangroves because if opens at the wrong place Inhabitants do not want mangroves Suggests to build an island and plan mangroves

Table A-3.12 Calumpit Focus Group Discussion Results

QUESTION / MUNICIPALITY / BARANGAY	CALUMPIT
1. Distance of Houses from Coastline	20 km (San Miguel)
2. Natural Resources Used in Daily Life	Livelihood: Fishing (ulang) Livelihood: Farming
3. Where Floodwaters Come From	Narrowing of river width Shallow riverbed Flood gates Land Subsidence High Tide
4. Warning Signs of Imminent Flooding	LGU Calendar MDRRMC: Text messages
5. Hours Between Receiving Warning and Flooding	2-3 days
6. Activities Preparing for Flooding Threat	raise belongings to higher places store food Harvest fish
7. Frequency of Flooding	High Tide: San Jose High Tide: San Miguel High Tide: Sta. Lucia High Tide: Bugo High Tide: Bulusan Every Typhoon
8. Depth of Floodwaters	>1.5m chest level knee level
9. Causes of Flooding	elevation of roads high tide Narrowing of river width construction waste along river banks drainage system solid wastes
10. Community/Association Initiatives	Samahan ng magsasaka (San Jose) Samahan ng magsasaka (San Miguel) Samahan ng magsasaka (Sta. Lucia) Samahan ng magsasaka (Bugo) Samahan ng magsasaka (Bulusan) Samahan ng mangingisda sa Meyto Samahan ng magsasaka sa Meyto
11. Provincial/Municipal Govt Intitiatives	Water Lily Cleaning Act Gugo Capital lending
12. Expectations from Nature-Based Solutions	
13. Advantages of Nature-Based Solutions	Wave reduction
14. Disadvantages of Nature-Based Solutions	Mangroves will block waters which will lead to flooding Growing mangroves in the coast line does not affect them Growing mangroves will only lead water to get stuck in Calumpit from upstream areas

15. Concerns on Implementation	water level rise raising of road elevations by the government did not resolve flooding Saltwater intrusion from floodgate structures Water lilies obstructing fishing nets Rivers & saltwater/salinity level for fish growth Burak in the manila bay Pollution due to feeds illegal fishing saltwater intrusion to farm fields

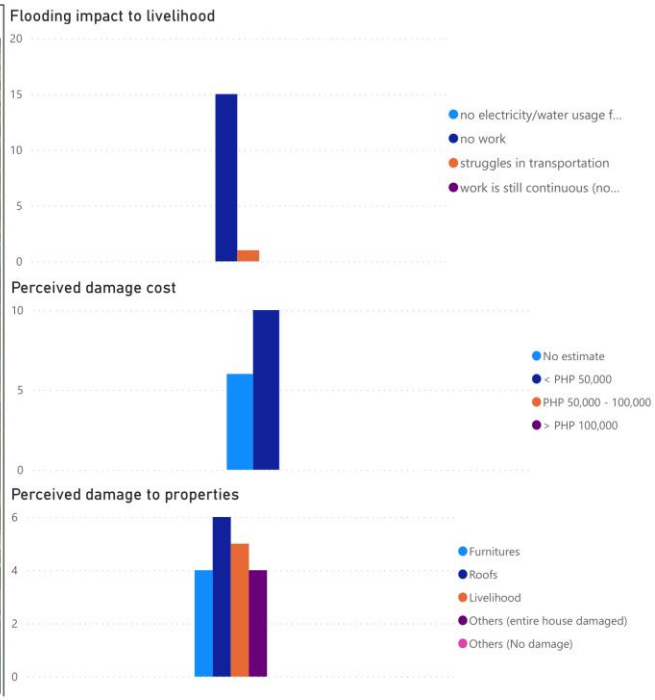
Table A-3.13 - Lubao Focus Group Discussion Results

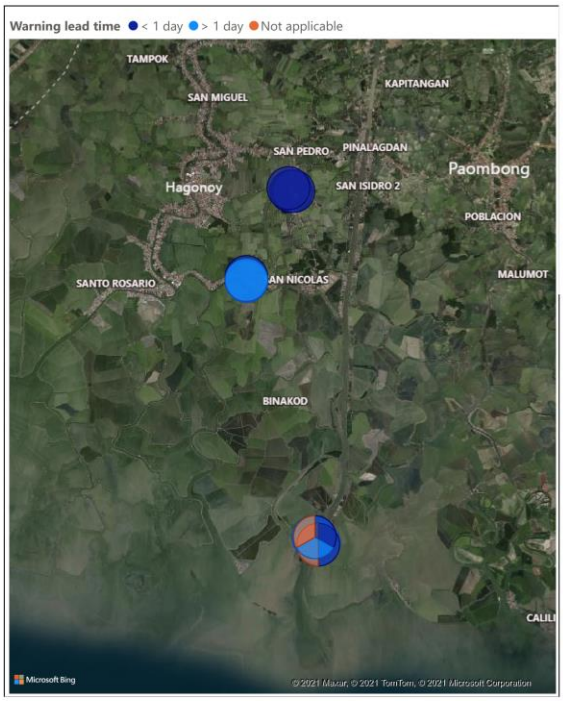
QUESTION / MUNICIPALITY / BARANGAY	LUBAO
1. Distance of Houses from Coastline	2km (Pugad Bancal)
2. Natural Resources Used in Daily Life	Livelihood: Fishing Transportation: Taxi boat Livelihood: Fishpond Security Livelihood: Fish pond Laborer Livelihood: LGU Employee
3. Where Floodwaters Come From	High Tide from Manila Bay Encounter: High Tide & Delta River Typhoons (example "Glenda") Habagat
4. Warning Signs of Imminent Flooding	LGU News Barangay System SMS
5. Hours Between Receiving Warning and Flooding	2 days before
6. Activities Preparing for Flooding Threat	Evacuation Organize belongings Secure roofs Tie boats raise belongings to higher places
7. Frequency of Flooding	2 weeks during Typhoon glenda
8. Depth of Floodwaters	>1.5m
9. Causes of Flooding	Garbage Land Subsidence (Deep Well) No drainage (gutter only) Upstream Water
10. Community/Association Initiatives	No associations
11. Provincial/Municipal Govt Intitiatives	Livelihood support such as provision of fishnet, and boat items
12. Expectations from Nature-Based Solutions	Increase livelihood Opportunity for income
13. Advantages of Nature-Based Solutions	Opportunity for Tourism More fishes and oysters Develop mangrove plantation No more structures
14. Disadvantages of Nature-Based Solutions	Garbage Manpower to maintain
15. Concerns on Implementation	Flooded fishing areas during typhoon No one to watching closely to fish shockers Garbage is in riverbed Chemical foods (poison)

A.3.3 Household Survey Results

A.3.3.1 Hagonoy, Bulacan


Perceived flood depth
Chest Level
Knee Level
Neck Level
Shoulder Le...
Waist Level
TAMPOK
SAN MIGUEL
KAPITANGAN
SAN PEDRO
PINALAGDAN
Paombong
Hagonoy
SAN ISIDRO 2
POBLACION
SANTO ROSARIO
AN NICOLAS
MALUMOT
BINAKOD
CALILI
Microsoft Bing
© 2021 Maxar, © 2021 TomTom, © 2021 Microsoft Corporation


Flooding impact to livelihood
20
15
10
5
0
no electricity/water usage f...
no work
struggles in transportation
work is still continuous (no...
Perceived damage cost
10
5
0
No estimate
< PHP 50,000
PHP 50,000 - 100,000
> PHP 100,000
Perceived damage to properties
6
4
2
0
Furnitures
Roofs
Livelihood
Others (entire house damaged)
Others (No damage)


Warning lead time
< 1 day
> 1 day
Not applicable
TAMPOK
SAN MIGUEL
KAPITANGAN
SAN PEDRO
PINALAGDAN
Paombong
Hagonoy
SAN ISIDRO 2
POBLACION
SANTO ROSARIO
AN NICOLAS
MALUMOT
BINAKOD
CALILI
Microsoft Bing
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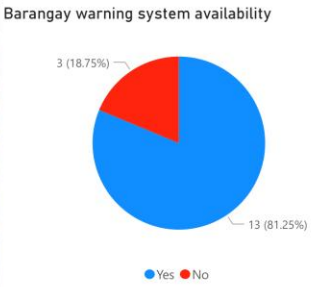
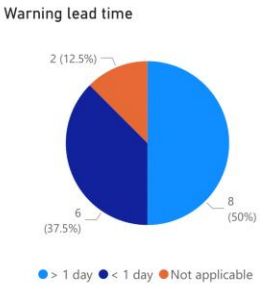
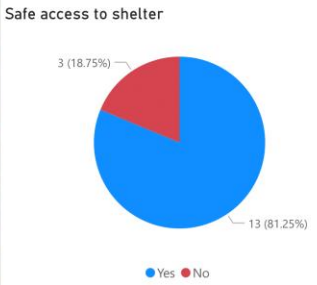
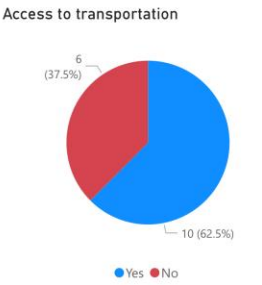
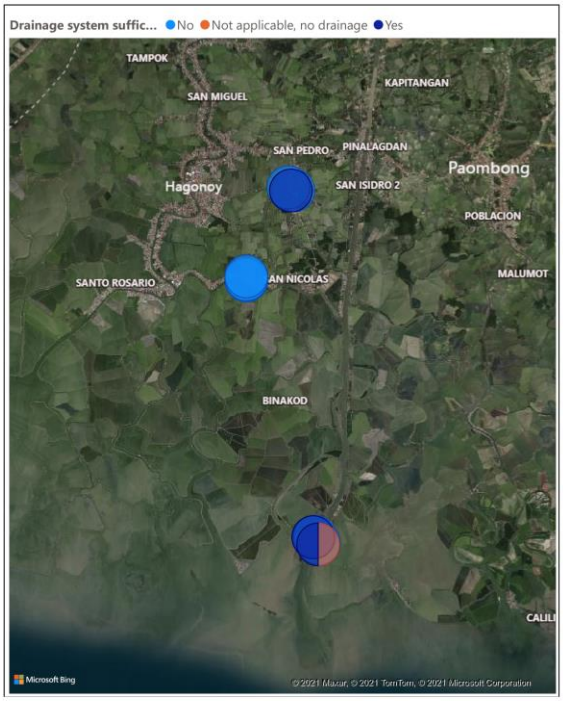

Barangay warning system availability
3 (18.75%)
13 (81.25%)
Yes
No


Warning lead time
2 (12.5%)
8
(50%)
6
(37.5%)
> 1 day
< 1 day
Not applicable


Safe access to shelter
3 (18.75%)
13 (81.25%)
Yes
No


Access to transportation
6
(37.5%)
10 (62.5%)
Yes
No


Drainage system suffic... No Not applicable, no drainage Yes
TAMPOK
KAPITANGAN
SAN MIGUEL
SAN PEDRO
PINALAGDAN
Paombong
Hagonoy
SAN ISIDRO 2
POBLACION
SANTO ROSARIO
AN NICOLAS
MALUMOT
BINAKOD
CALILI
Microsoft Bing
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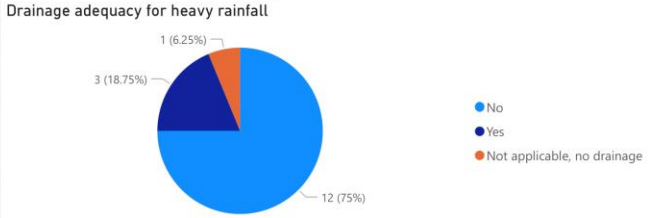
Hazard Preparation Measures
10
5
0
Store food, Store water, Store m...
Secure roofs
Evacuate to shelter
Evacuate to neighbour
Evacuate to family / friends outs...
Raise belongings to higher places
Nothing
Other
Hazard Reduction Measures
10
5
0
Assist in maintaining drainage
Assist in maintaining trees or ma...
Assist in maintaining sea walls
Building house on stils or constr...
Use stronger building materials
Others


Drainage adequacy for heavy rainfall
1 (6.25%)
3 (18.75%)
12 (75%)
No
Yes
Not applicable, no drainage


Projects (5 years) No change Yes, improved Yes, worsened
TAMPOK
KAPITANGAN
SAN MIGUEL
SAN PEDRO
PINALAGDAN
Paombong
Hagonoy
SAN ISIDRO 2
POBLACION
SANTO ROSARIO
AN NICOLAS
MALUMOT
BINAKOD
CALILI
Microsoft Bing
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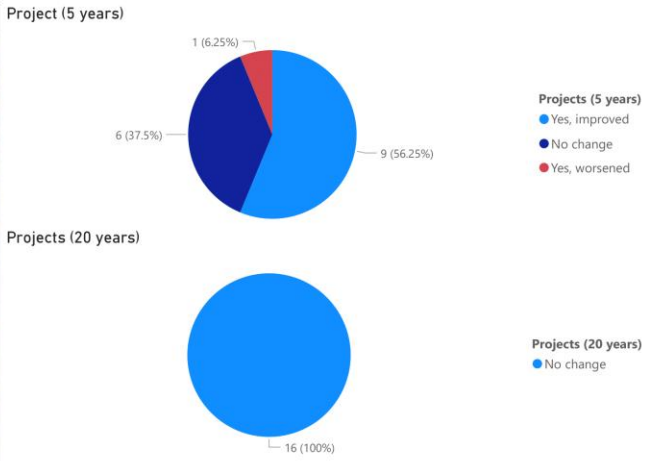
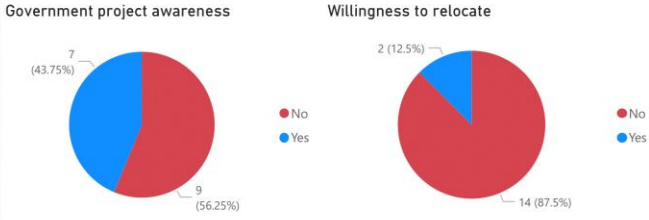
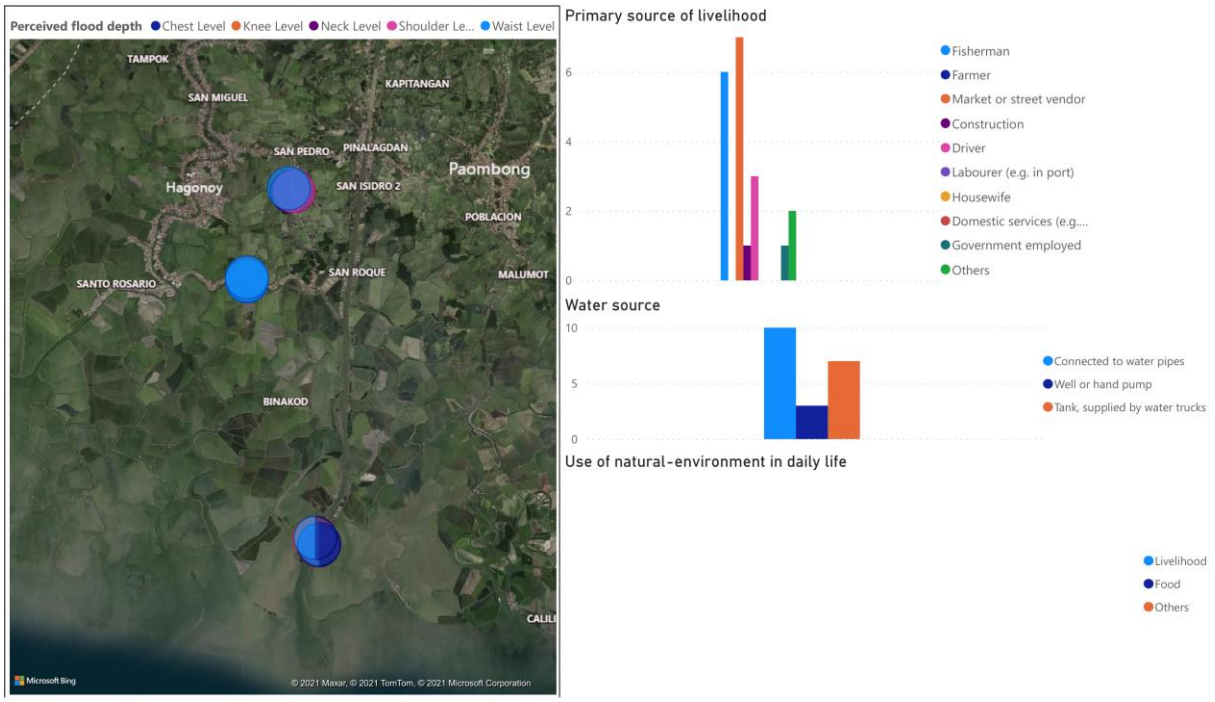
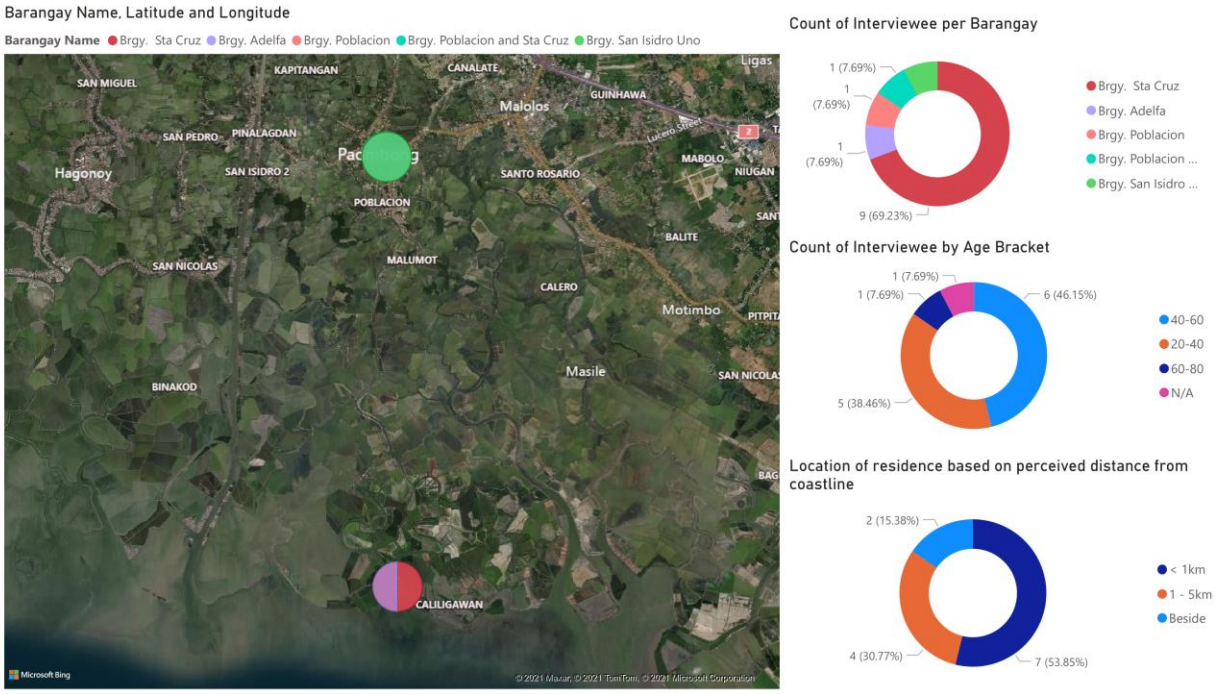

Project (5 years)
1 (6.25%)
6 (37.5%)
9 (56.25%)
Projects (5 years)
Yes, improved
No change
Yes, worsened

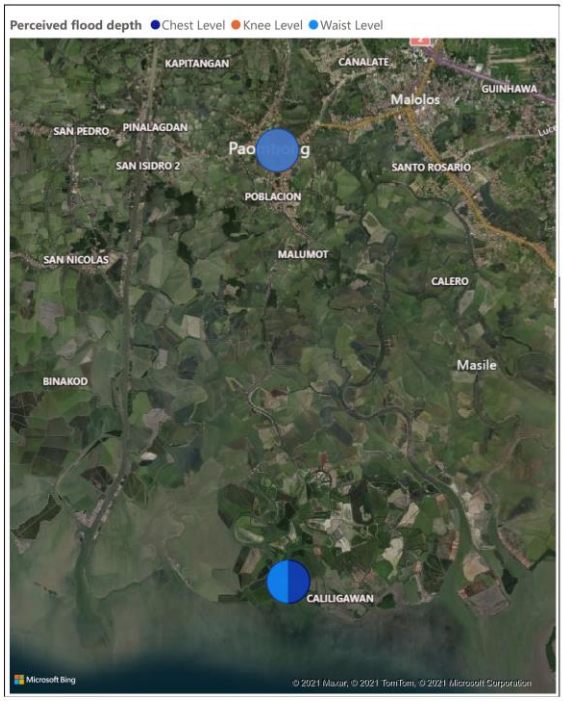
Projects (20 years)
16 (100%)
Projects (20 years)
No change


Government project awareness
7
(43.75%)
9
(56.25%)
No
Yes
Willingness to relocate
2 (12.5%)
14 (87.5%)
No
Yes



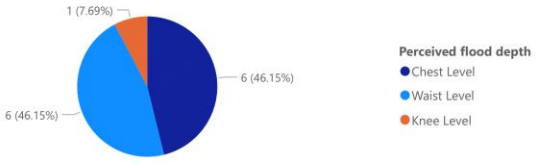
A.3.3.2 Paombong, Bulacan



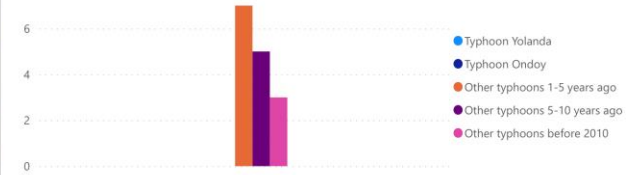


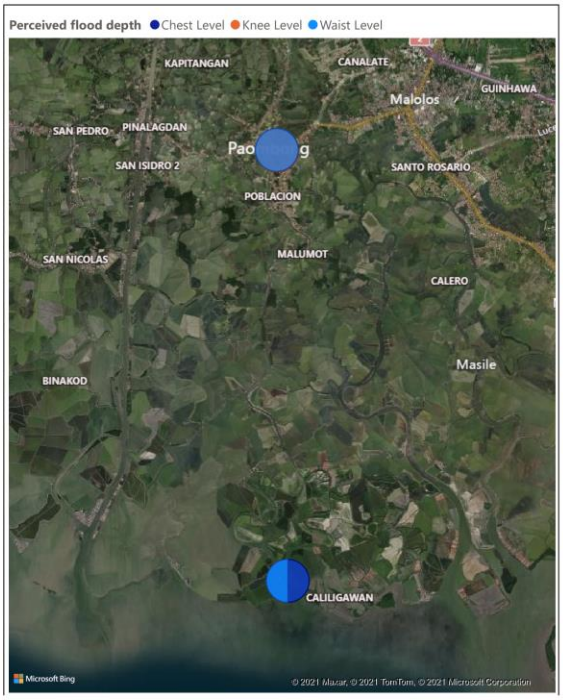
Perceived Coastal Hazard Source

Perceived flood depth

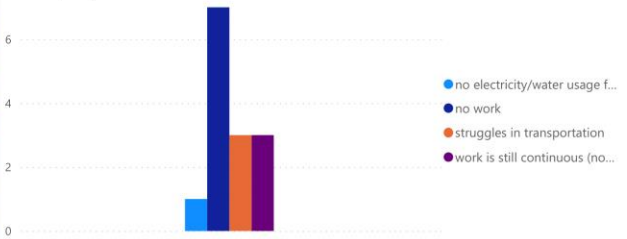


Strongest typhoon experienced

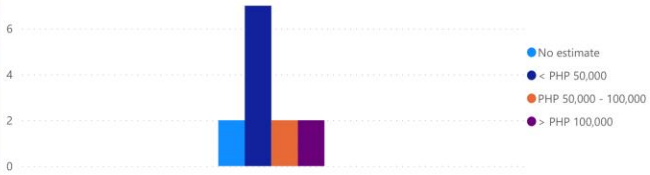




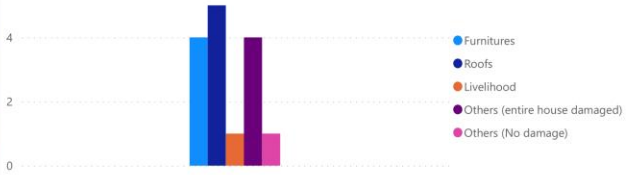
Flooding impact to livelihood

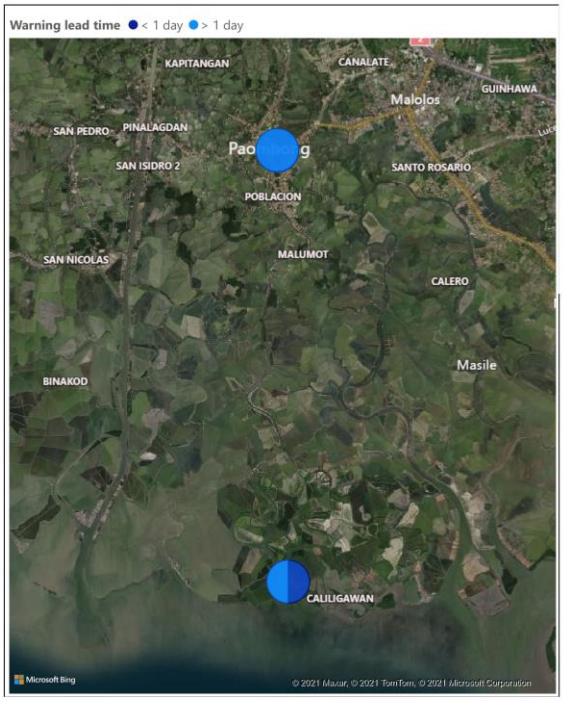


Perceived damage cost

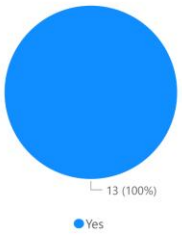


Perceived damage to properties

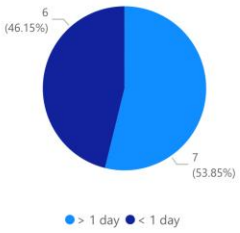




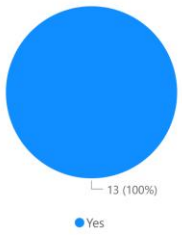
Barangay warning system availability



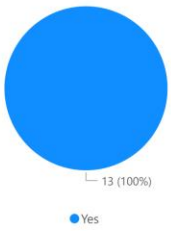
Warning lead time

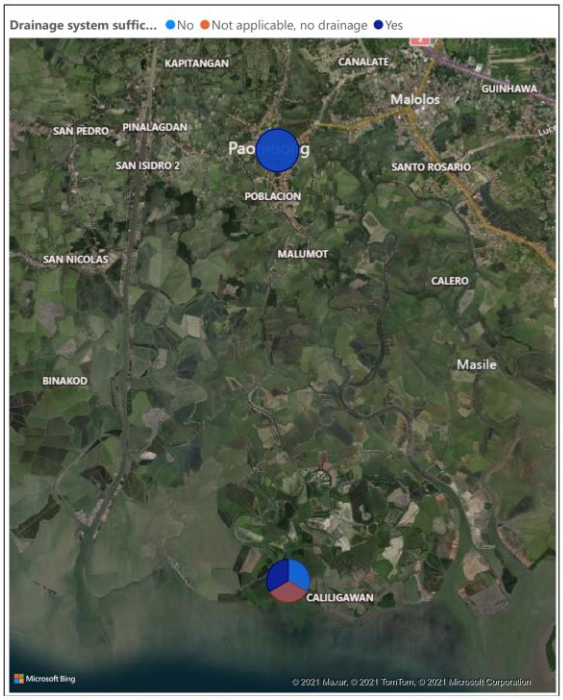


Safe access to shelter

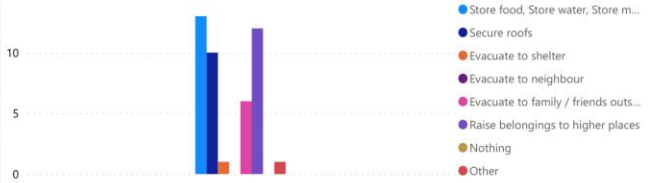


Access to transportation

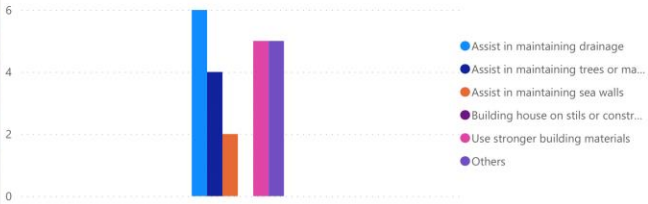




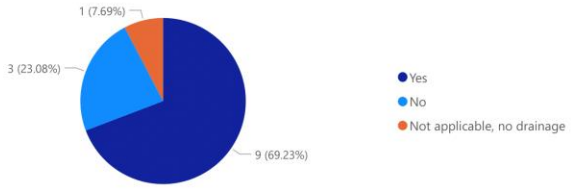
Hazard Preparation Measures

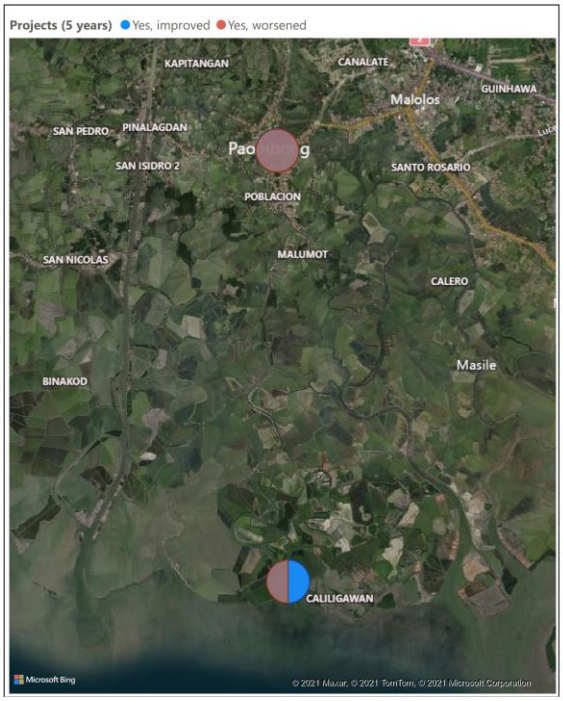


Hazard Reduction Measures

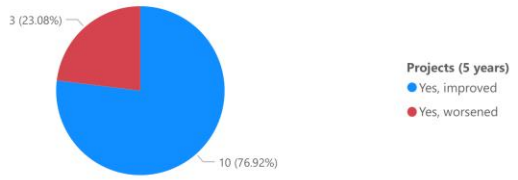


Drainage adequacy for heavy rainfall

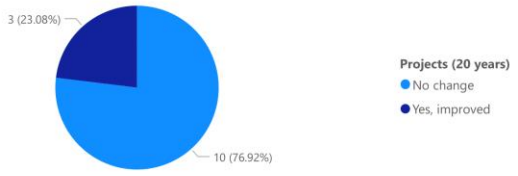




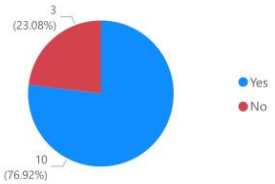
Project (5 years)



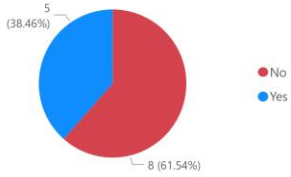
Projects (20 years)



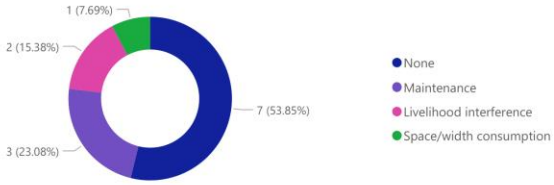
Government project awareness



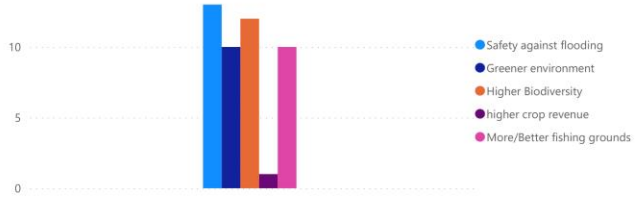
Willingness to relocate

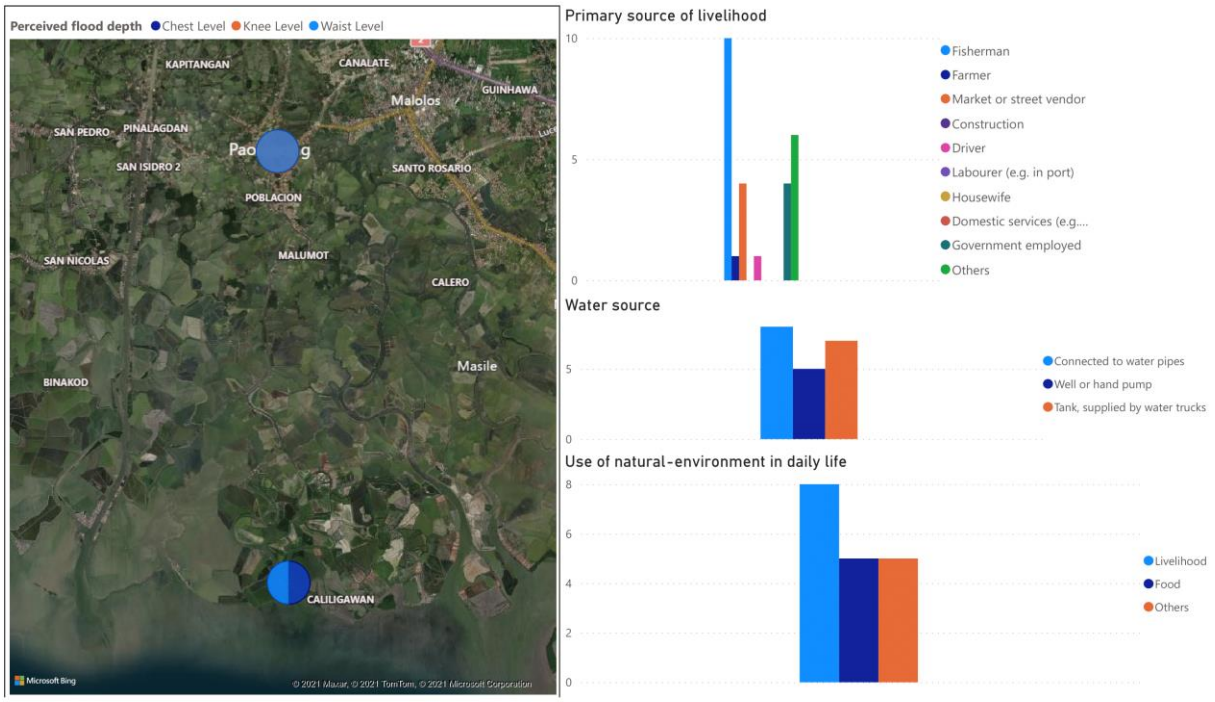


Mangrove forest: Perceived Disadvantages/Challenges

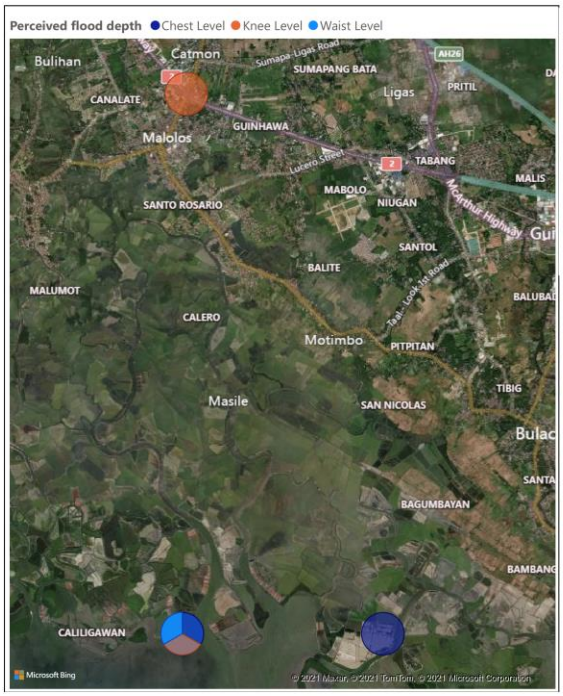


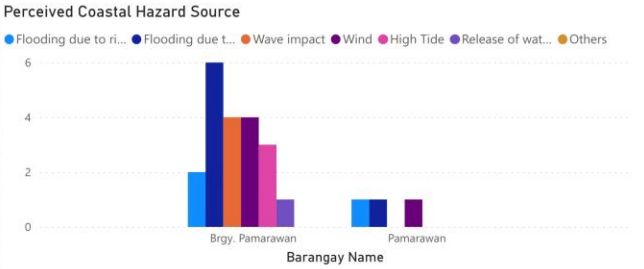
Perceived nature-based solution benefits

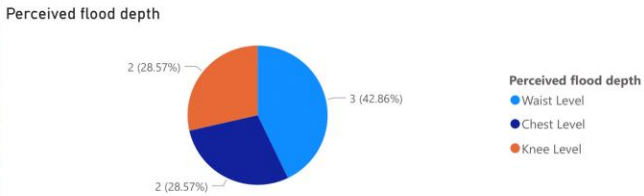


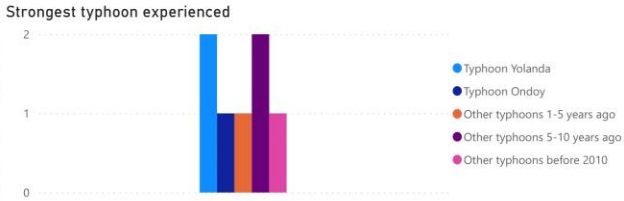


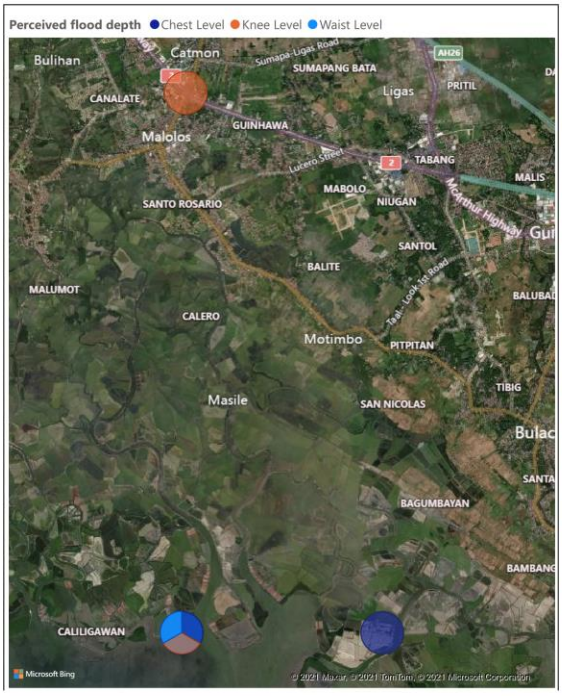
A.3.3.3 Malolos, Bulacan

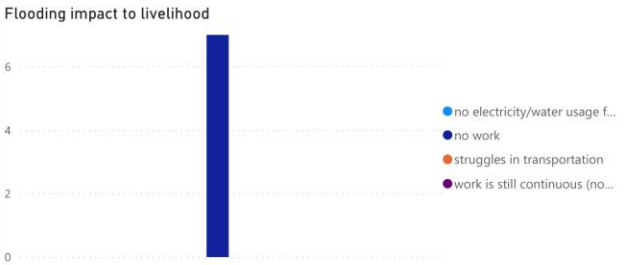

Perceived flood depth
Chest Level
Knee Level
Waist Level
Bulihan
Catmon
Sumapa-Ligas Road
SUMAPANG BATA
AH26
CANALATE
Ligas
PRITIL
GUINHAWA
Malolos
Lutero Street
TABANG
MALIS
MABOLO
NIUGAN
SANTO ROSARIO
MacArthur Highway
SANTOL
BALITE
MALUMOT
Tabt.-Look-to Road
BALUBAL
CALERO
Motimbo
PITPITAN
TIBIG
Masile
SAN NICOLAS
Bulac
BAGUMBAYAN
CALILIGAWAN
Microsoft Bing

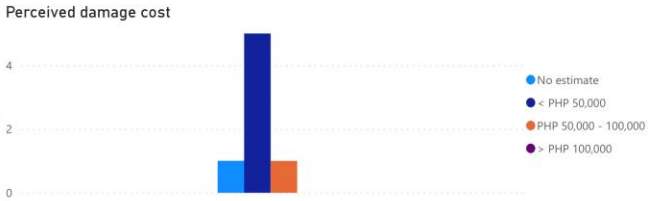

Perceived Coastal Hazard Source
Flooding due to ri...
Flooding due t...
Wave impact
Wind
High Tide
Release of wat...
Others
6
4
2
0
Brgy. Pamarawan
Pamarawan
Barangay Name

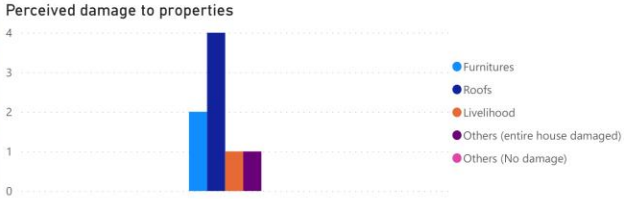

Perceived flood depth
2 (28.57%)
3 (42.86%)
2 (28.57%)
Perceived flood depth
Waist Level
Chest Level
Knee Level

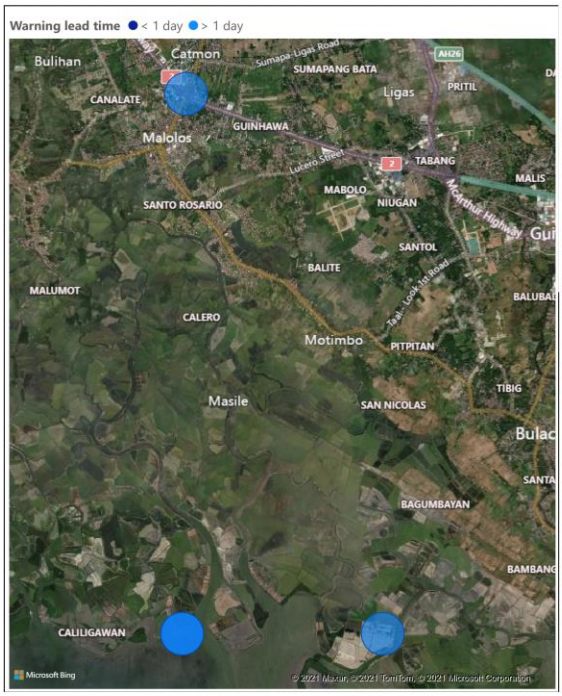

Strongest typhoon experienced
2
1
0
Typhoon Yolanda
Typhoon Ondoy
Other typhoons 1-5 years ago
Other typhoons 5-10 years ago
Other typhoons before 2010


Perceived flood depth
Chest Level
Knee Level
Waist Level
Bulihan
Catmon
Sumapa-Ligas Road
SUMAPANG BATA
AH26
CANALATE
Ligas
PRITIL
GUINHAWA
Malolos
Lutero Street
TABANG
MALIS
MABOLO
NIUGAN
SANTO ROSARIO
MacArthur Highway
SANTOL
BALITE
MALUMOT
Tabt.-Look-to Road
BALUBAL
CALERO
Motimbo
PITPITAN
TIBIG
Masile
SAN NICOLAS
Bulac
BAGUMBAYAN
CALILIGAWAN
Microsoft Bing

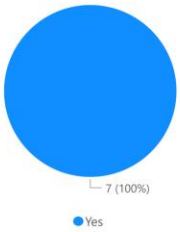

Flooding impact to livelihood
6
4
2
0
no electricity/water usage f...
no work
struggles in transportation
work is still continuous (no...


Perceived damage cost
4
2
0
No estimate
< PHP 50,000
PHP 50,000 - 100,000
> PHP 100,000

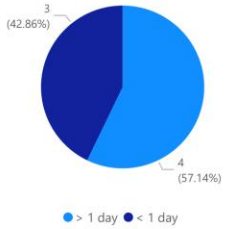

Perceived damage to properties
4
3
2
1
0
Furnitures
Roofs
Livelihood
Others (entire house damaged)
Others (No damage)



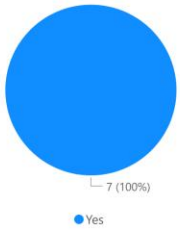
Barangay warning system availability



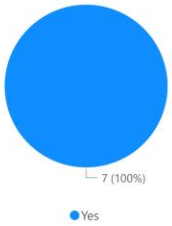
Warning lead time

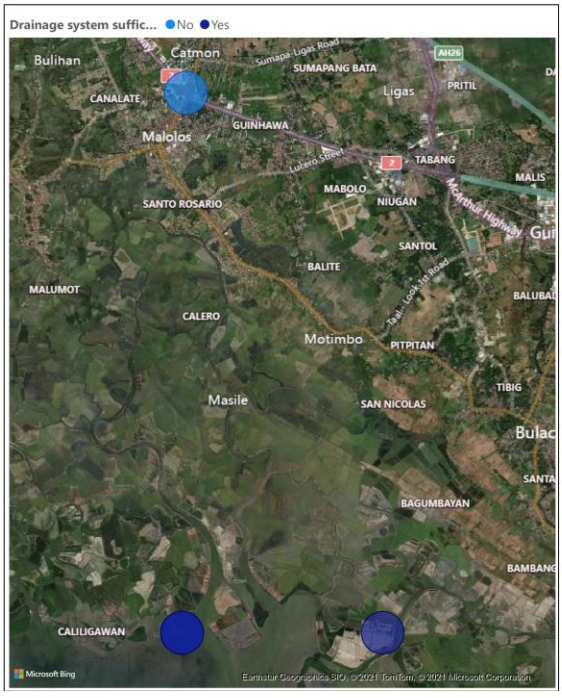


Safe access to shelter

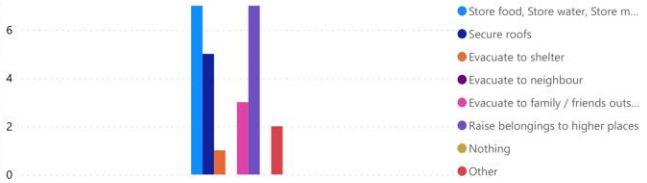


Access to transportation

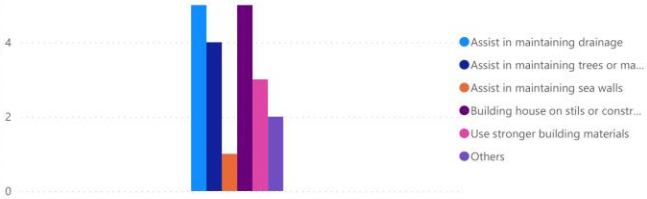




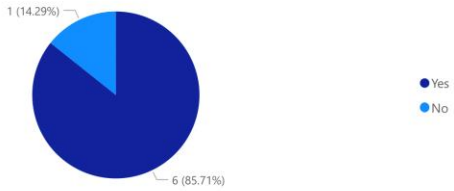
Hazard Preparation Measures

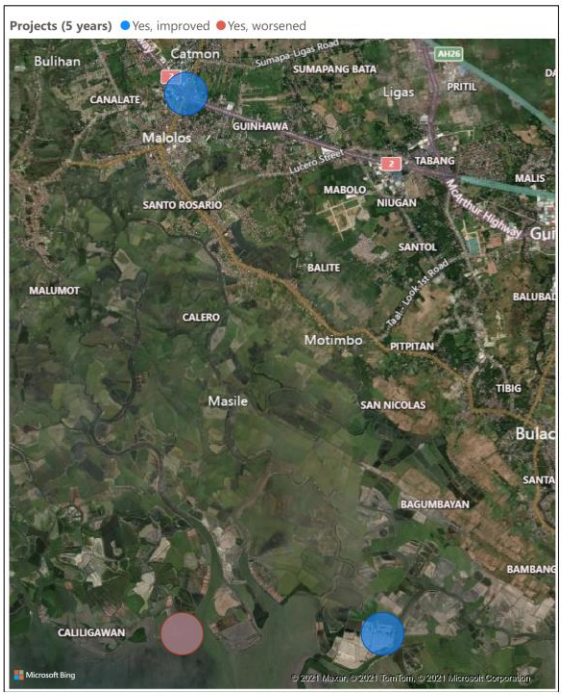


Hazard Reduction Measures

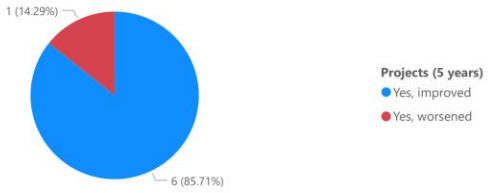


Drainage adequacy for heavy rainfall

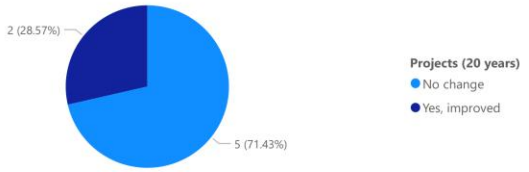




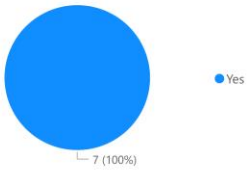
Project (5 years)



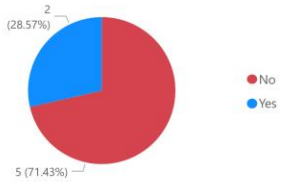
Projects (20 years)

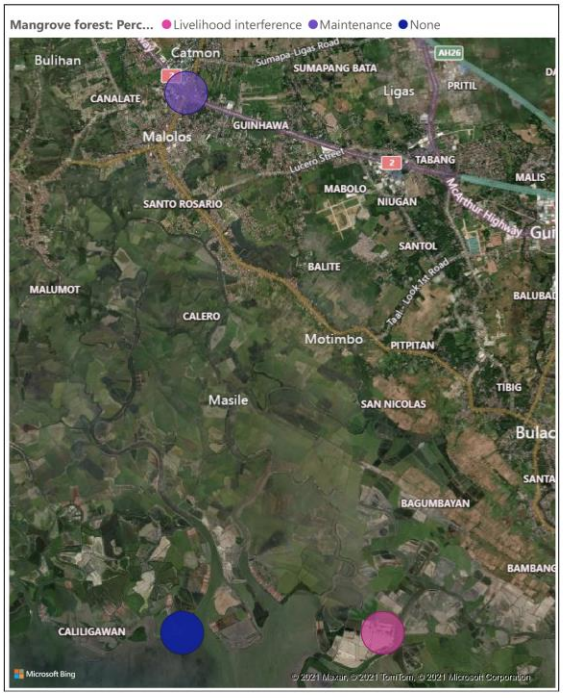


Government project awareness

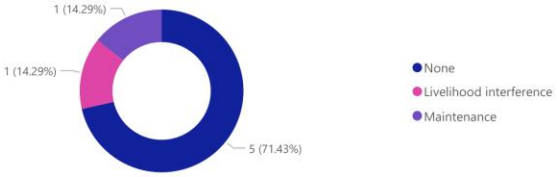


Willingness to relocate

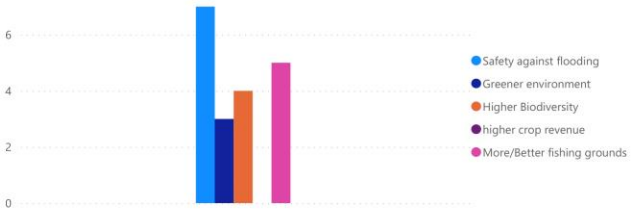


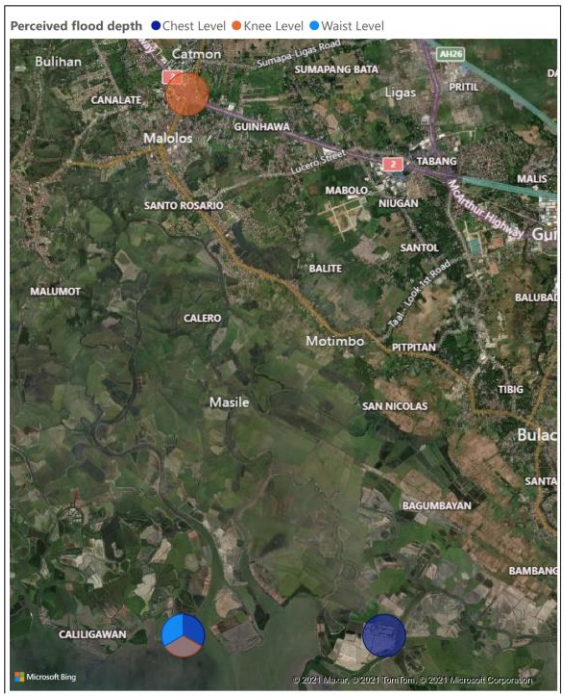


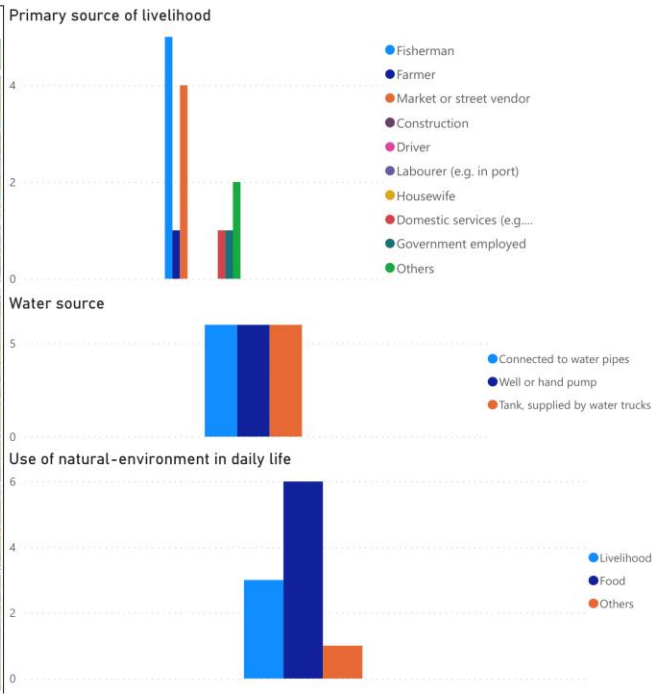
Mangrove forest: Perceived Disadvantages/Challenges



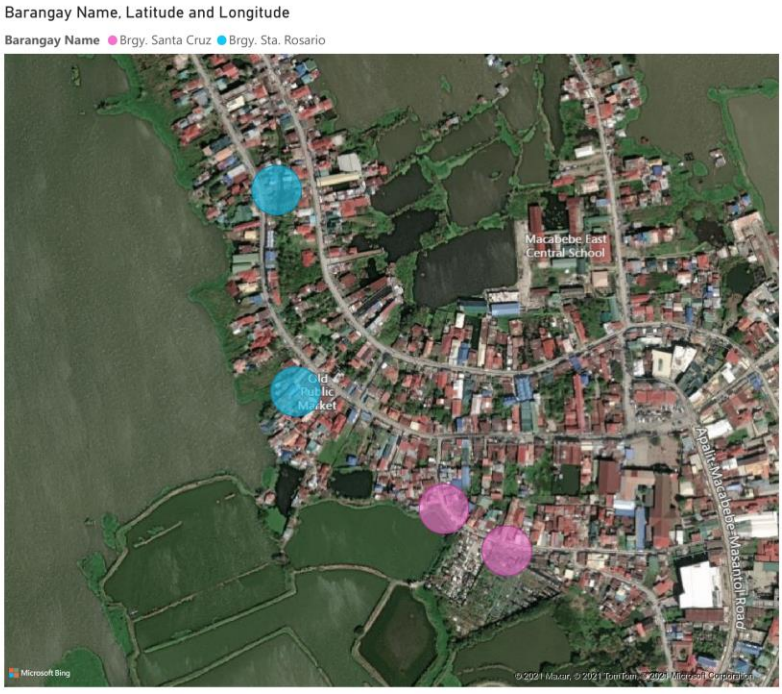
Perceived nature-based solution benefits

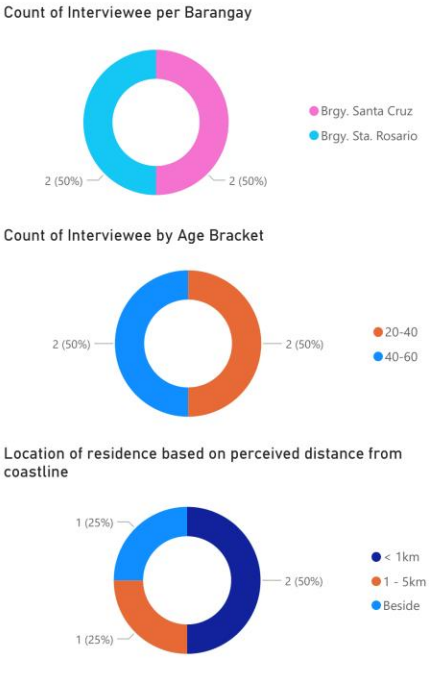




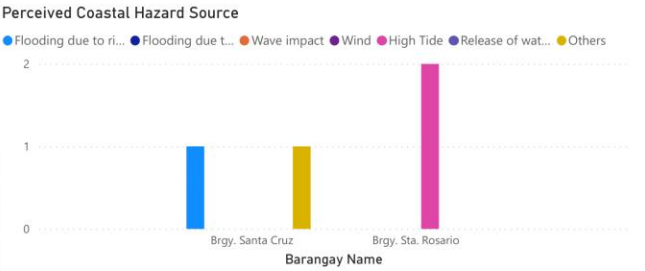


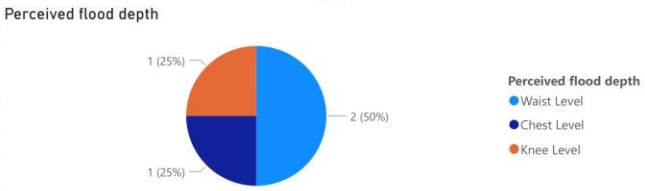
A.3.3.4 Macabebe, Pampanga

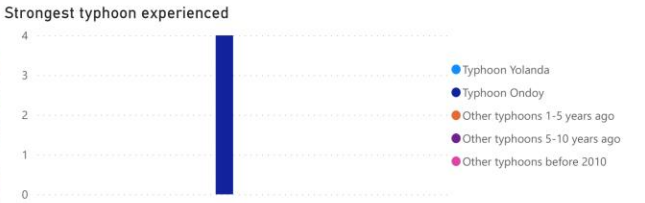





Perceived flood depth
Chest Level
Knee Level
Waist Level
Macabebe East Central School
Old Public Market
Microsoft Bing

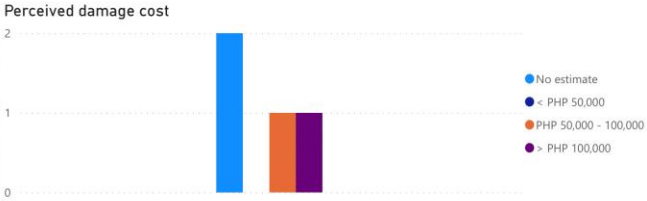

Perceived Coastal Hazard Source
Flooding due to ri...
Flooding due t...
Wave impact
Wind
High Tide
Release of wat...
Others
2
1
0
Brgy. Santa Cruz
Brgy. Sta. Rosario
Barangay Name

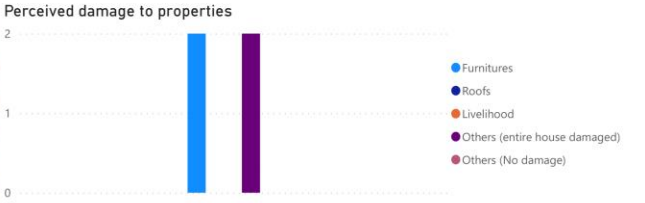

Perceived flood depth
1 (25%)
2 (50%)
1 (25%)
Perceived flood depth
Waist Level
Chest Level
Knee Level


Strongest typhoon experienced
4
3
2
1
0
Typhoon Yolanda
Typhoon Ondoy
Other typhoons 1-5 years ago
Other typhoons 5-10 years ago
Other typhoons before 2010

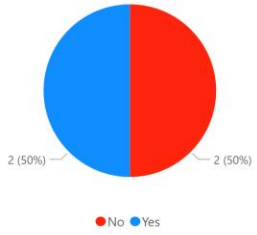

Perceived flood depth
Chest Level
Knee Level
Waist Level
Macabebe East Central School
Old Public Market
Microsoft Bing


Flooding impact to livelihood
4
3
2
1
0
no electricity/water usage f...
no work
struggles in transportation
work is still continuous (no...

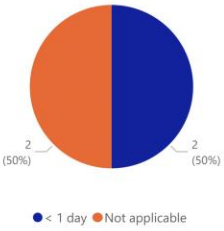

Perceived damage cost
2
1
0
No estimate
< PHP 50,000
PHP 50,000 - 100,000
> PHP 100,000


Perceived damage to properties
2
1
0
Furnitures
Roofs
Livelihood
Others (entire house damaged)
Others (No damage)

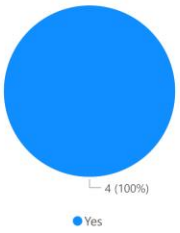
Barangay warning system availability



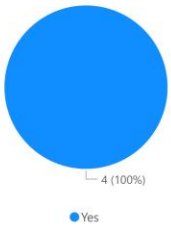
Warning lead time



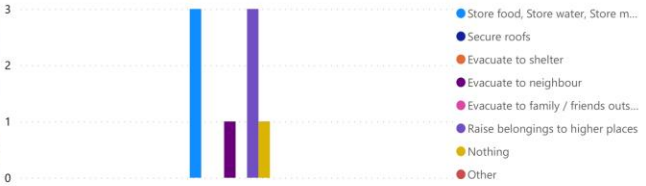
Safe access to shelter



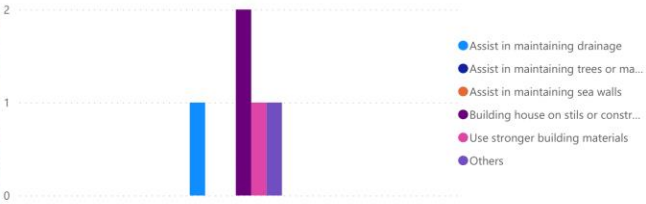
Access to transportation



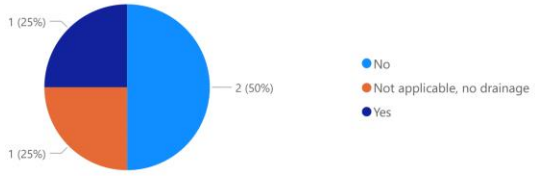
Hazard Preparation Measures



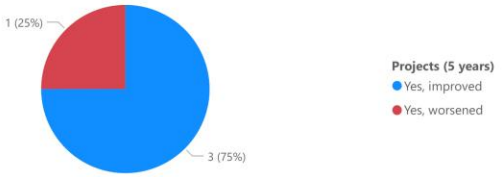
Hazard Reduction Measures



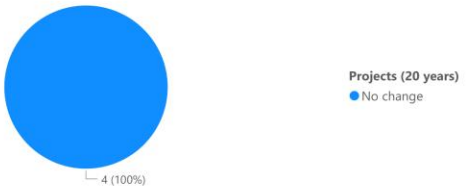
Drainage adequacy for heavy rainfall



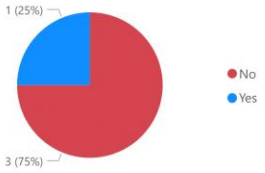
Project (5 years)



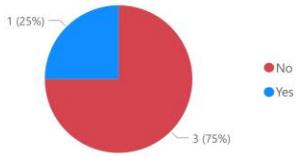
Projects (20 years)



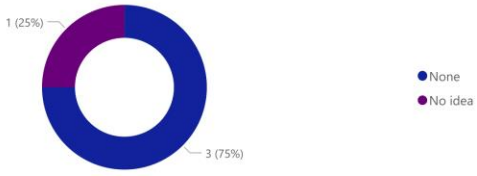
Government project awareness



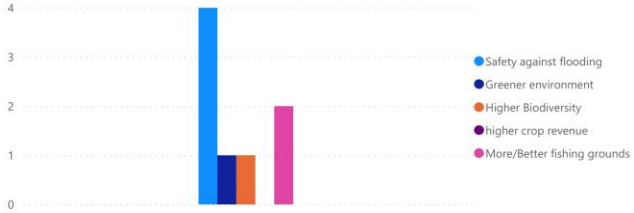
Willingness to relocate



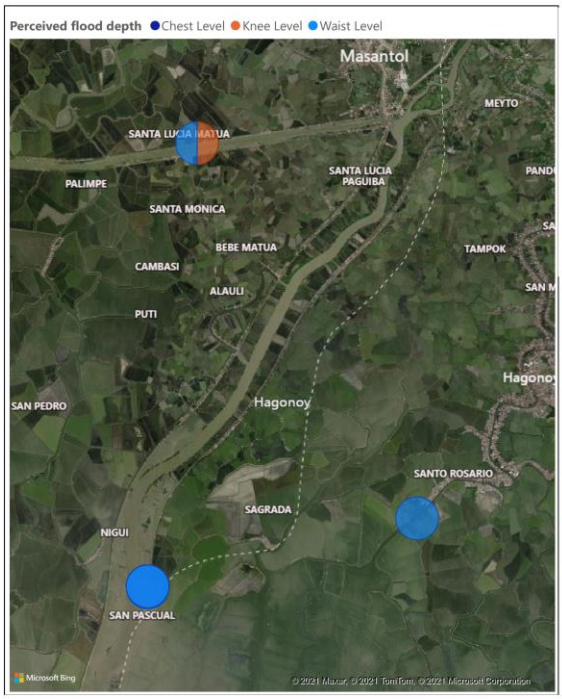
Mangrove forest: Perceived Disadvantages/Challenges

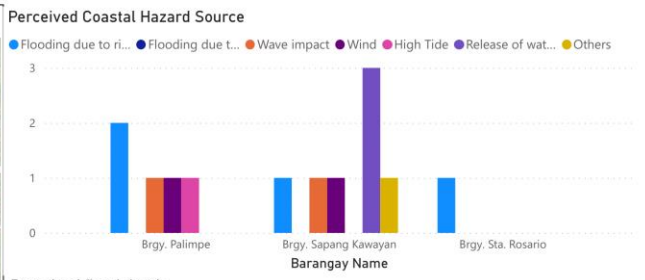


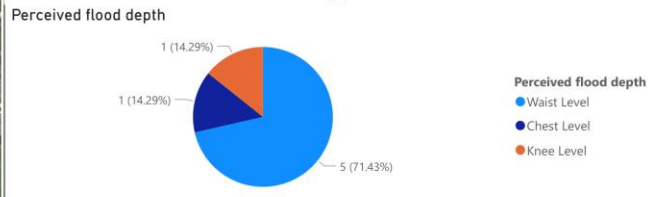
Perceived nature-based solution benefits

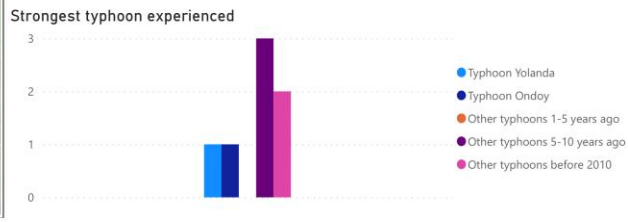


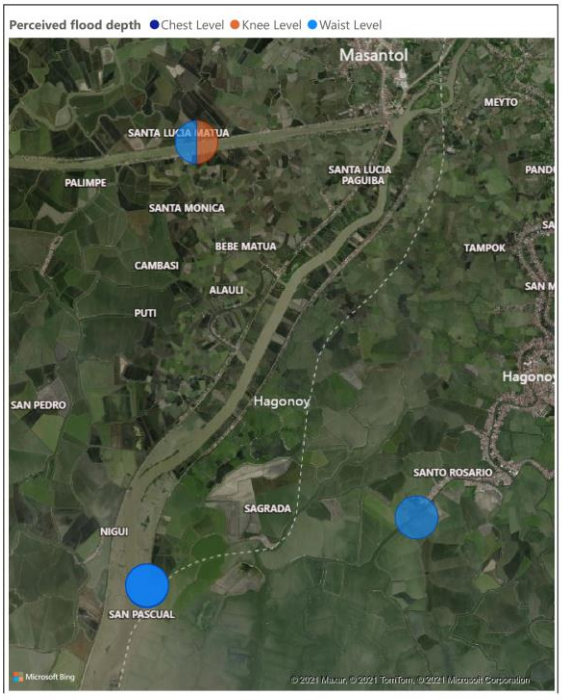
A.3.3.5 Masantol, Pampanga

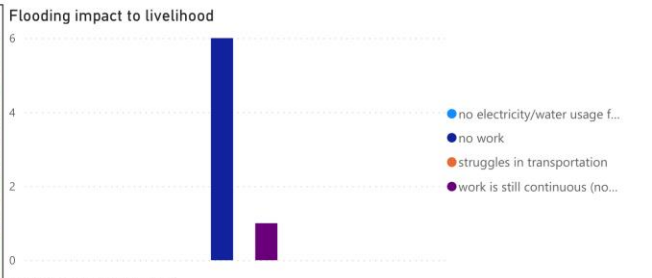

Perceived flood depth
Chest Level
Knee Level
Waist Level
Masantol
MEYTO
SANTA LUCIA MATUA
PALIMPE
SANTA LUCIA PAGUIBA
SANTA MONICA
BEBE MATUA
TAMPOK
CAMBASI
ALAULI
PUTI
Hagonoy
SAN PEDRO
SANTO ROSARIO
SAGRADA
NIGUI
SAN PASCUAL
Microsoft Bing

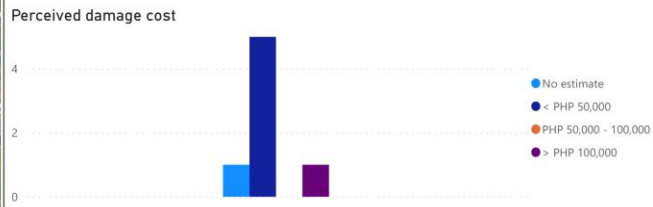

Perceived Coastal Hazard Source
Flooding due to ri...
Flooding due t...
Wave impact
Wind
High Tide
Release of wat...
Others
3
2
1
0
Brgy. Palimpe
Brgy. Sapang Kawayan
Brgy. Sta. Rosario
Barangay Name

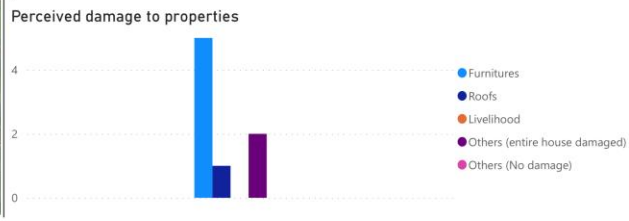

Perceived flood depth
1 (14.29%)
1 (14.29%)
5 (71.43%)
Perceived flood depth
Waist Level
Chest Level
Knee Level

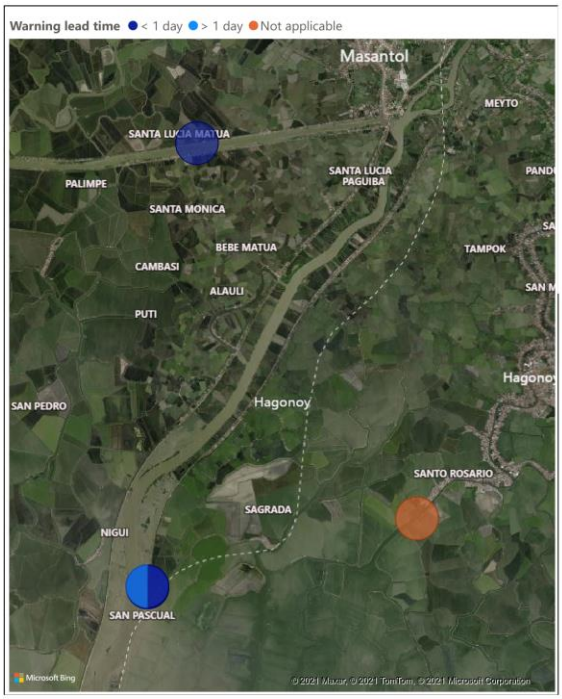

Strongest typhoon experienced
3
2
1
0
Typhoon Yolanda
Typhoon Ondoy
Other typhoons 1-5 years ago
Other typhoons 5-10 years ago
Other typhoons before 2010


Perceived flood depth
Chest Level
Knee Level
Waist Level
Masantol
MEYTO
SANTA LUCIA MATUA
PALIMPE
SANTA LUCIA PAGUIBA
SANTA MONICA
BEBE MATUA
TAMPOK
CAMBASI
ALAULI
PUTI
Hagonoy
SAN PEDRO
SANTO ROSARIO
SAGRADA
NIGUI
SAN PASCUAL
Microsoft Bing

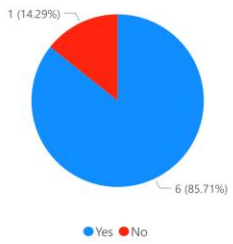

Flooding impact to livelihood
6
4
2
0
no electricity/water usage f...
no work
struggles in transportation
work is still continuous (no...


Perceived damage cost
4
2
0
No estimate
< PHP 50,000
PHP 50,000 - 100,000
> PHP 100,000

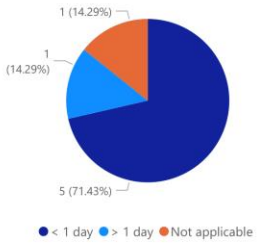

Perceived damage to properties
4
2
0
Furnitures
Roofs
Livelihood
Others (entire house damaged)
Others (No damage)



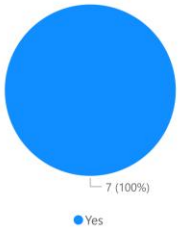
Barangay warning system availability



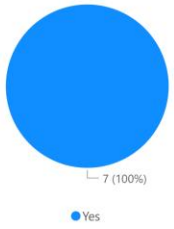
Warning lead time

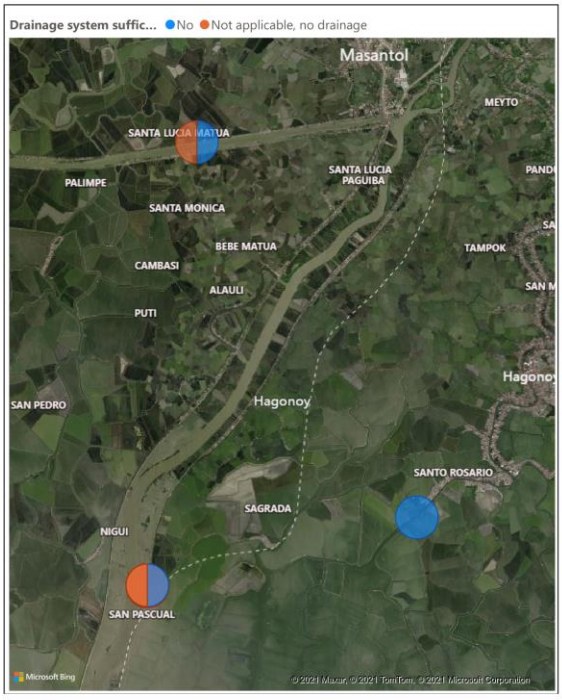


Safe access to shelter

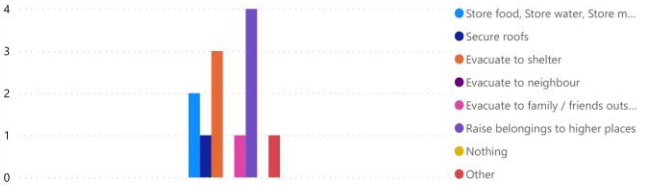


Access to transportation

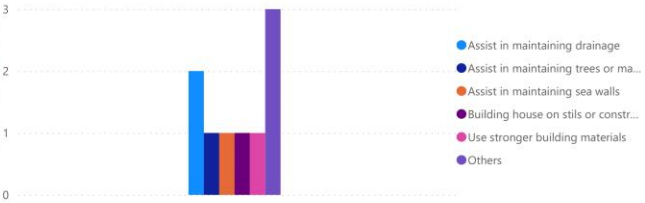




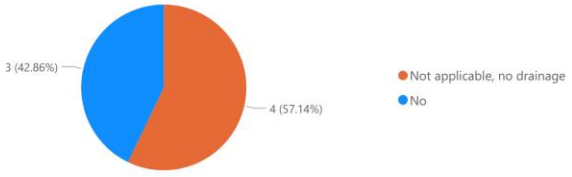
Hazard Preparation Measures

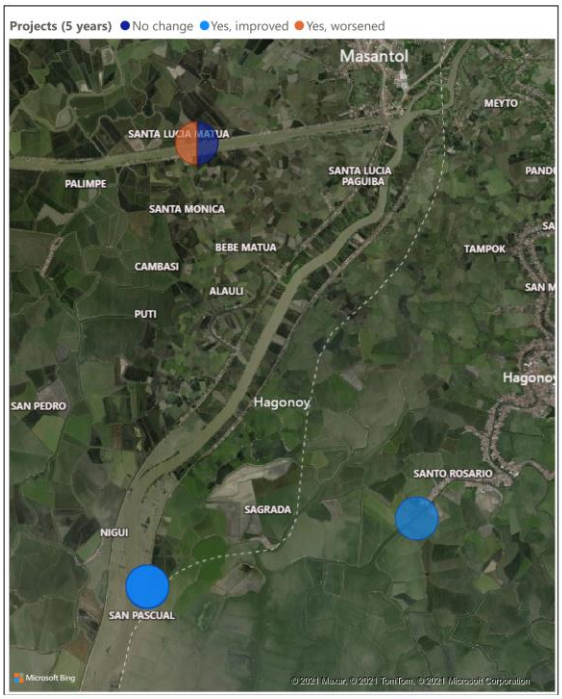


Hazard Reduction Measures

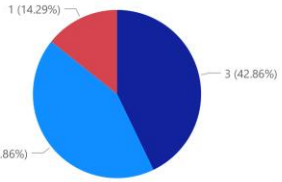


Drainage adequacy for heavy rainfall



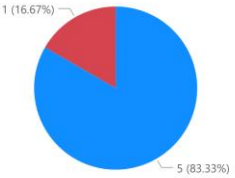


Project (5 years)



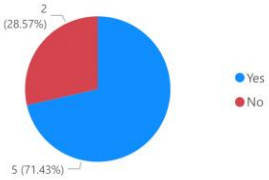
Projects (5 years)
No change
Yes, improved
Yes, worsened

Projects (20 years)

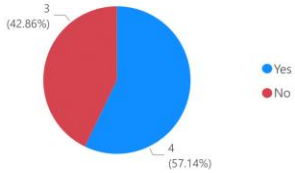


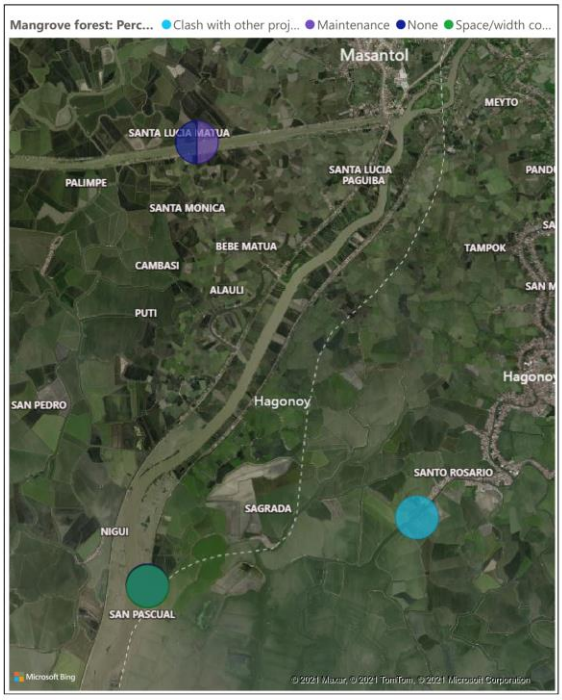
Projects (20 years)
No change
Yes, worsened

Government project awareness

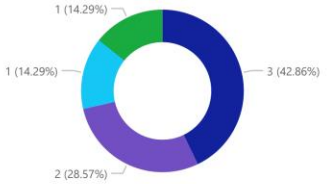


Willingness to relocate



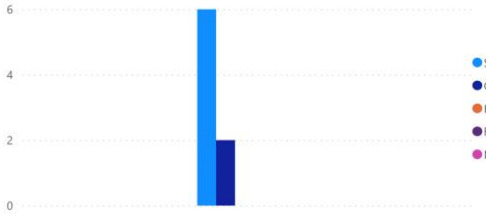


Mangrove forest: Perceived Disadvantages/Challenges

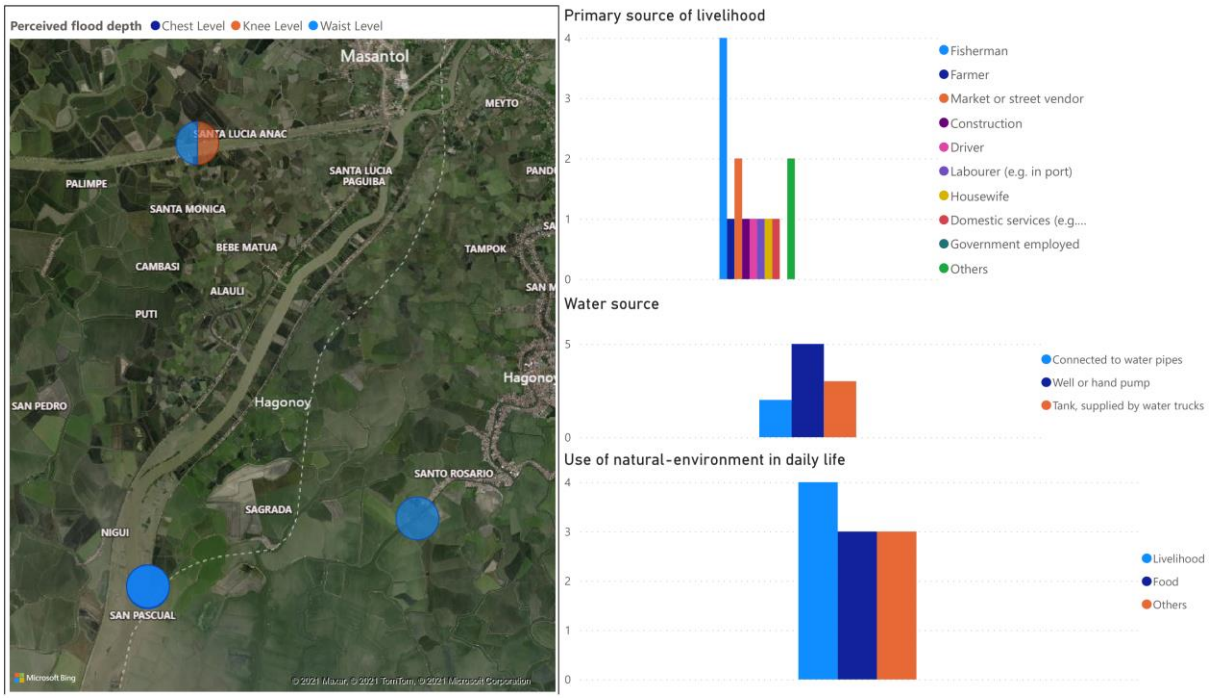


None
Maintenance
Clash with other projects (lik...
Space/width consumption

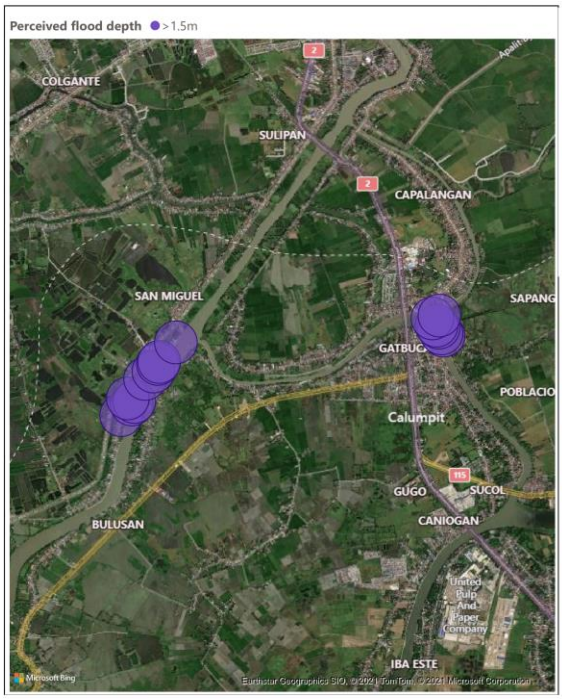
Perceived nature-based solution benefits

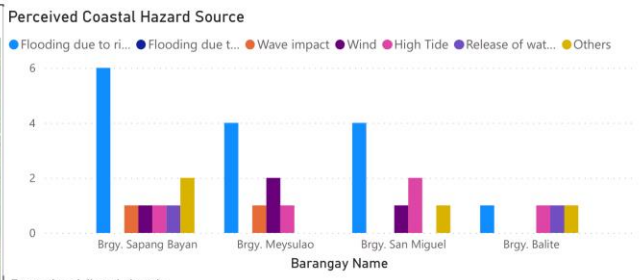


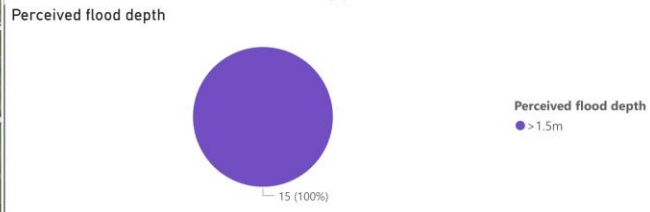
Safety against flooding
Greener environment
Higher Biodiversity
higher crop revenue
More/Better fishing grounds

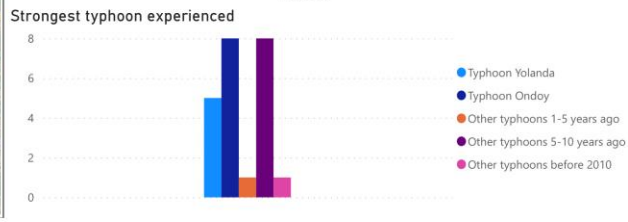


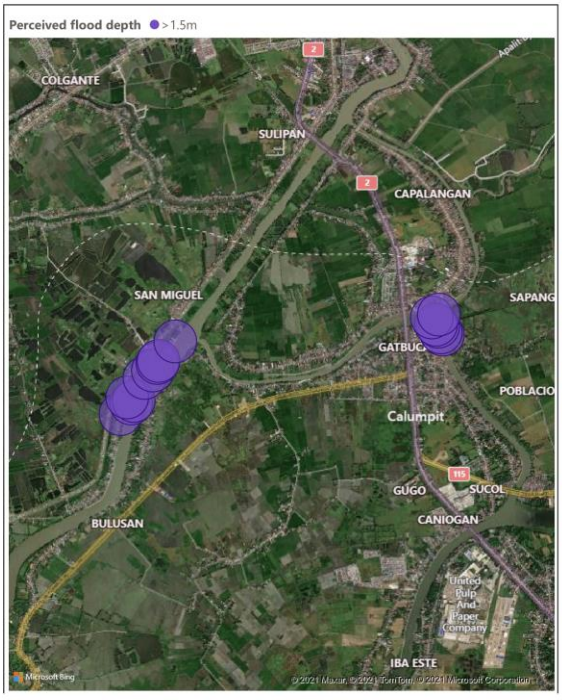
A.3.3.6 Calumpit, Bulacan

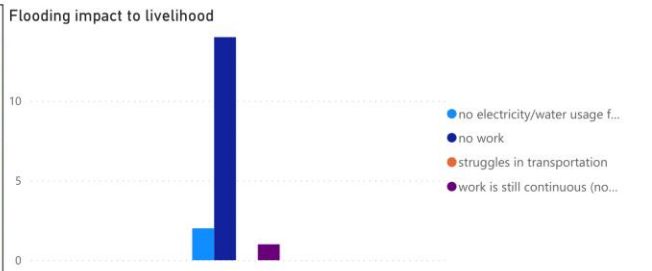

Perceived flood depth >1.5m
COLGANTE
SULIPAN
CAPALANGAN
SAN MIGUEL
SAPANG
GATBUCA
POBLACION
Calumpit
GUGO
SUCOL
BULUSAN
CANIOGAN
IBA ESTE
Microsoft Bing

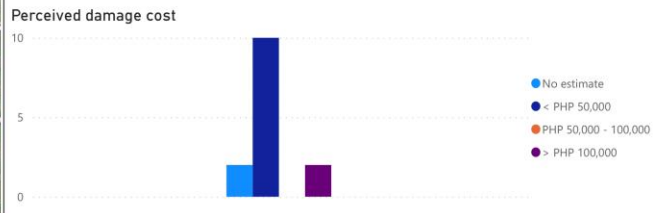

Perceived Coastal Hazard Source
Flooding due to ri...
Flooding due t...
Wave impact
Wind
High Tide
Release of wat...
Others
6
4
2
0
Brgy. Sapang Bayan
Brgy. Meysulao
Brgy. San Miguel
Brgy. Balite
Barangay Name

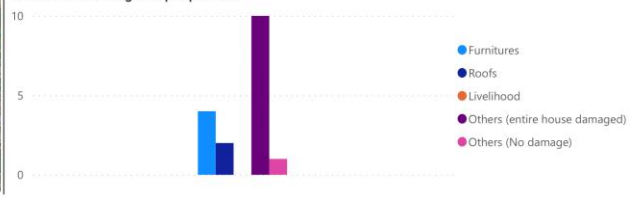

Perceived flood depth
15 (100%)
Perceived flood depth
>1.5m

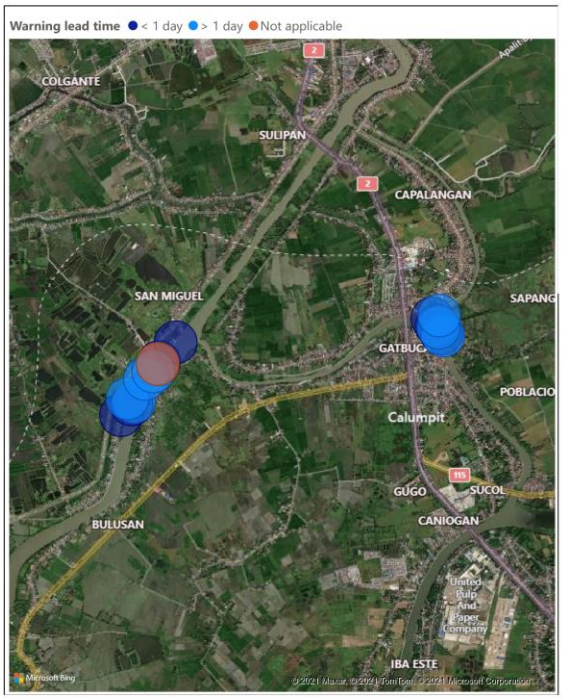

Strongest typhoon experienced
8
6
4
2
0
Typhoon Yolanda
Typhoon Ondoy
Other typhoons 1-5 years ago
Other typhoons 5-10 years ago
Other typhoons before 2010


Perceived flood depth >1.5m
COLGANTE
SULIPAN
CAPALANGAN
SAN MIGUEL
SAPANG
GATBUCA
POBLACION
Calumpit
GUGO
SUCOL
BULUSAN
CANIOGAN
IBA ESTE
Microsoft Bing

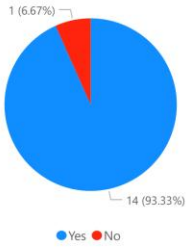

Flooding impact to livelihood
10
5
0
no electricity/water usage f...
no work
struggles in transportation
work is still continuous (no...


Perceived damage cost
10
5
0
No estimate
< PHP 50,000
PHP 50,000 - 100,000
> PHP 100,000

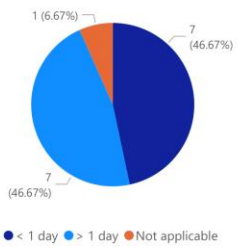

Perceived damage to properties
10
5
0
Furnitures
Roofs
Livelihood
Others (entire house damaged)
Others (No damage)



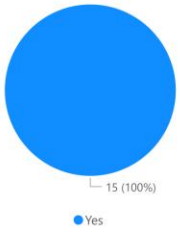
Barangay warning system availability



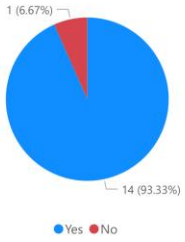
Warning lead time

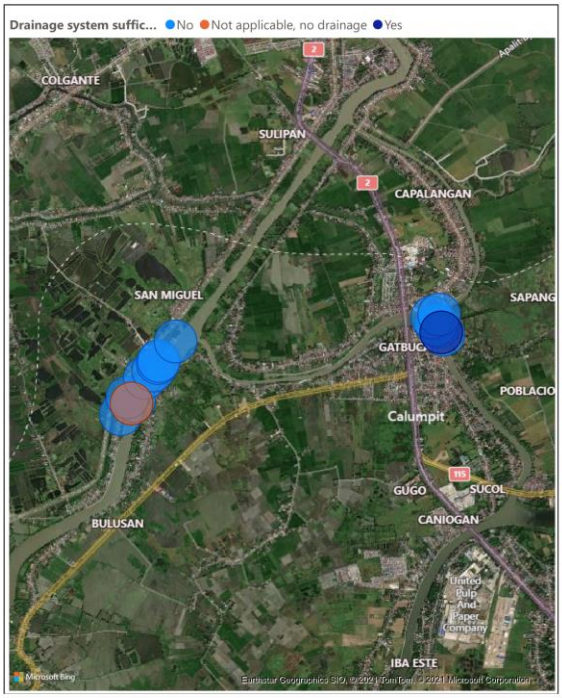


Safe access to shelter

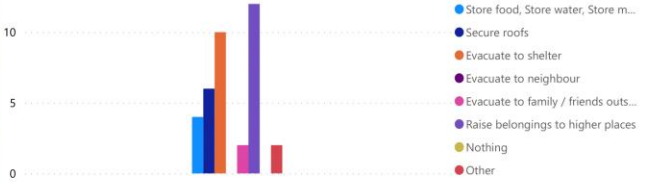


Access to transportation

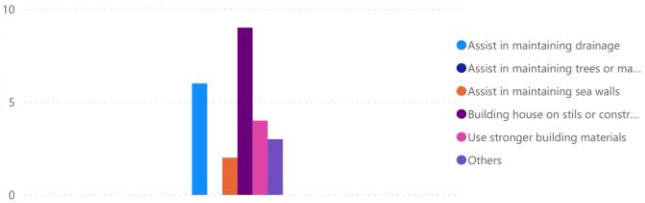




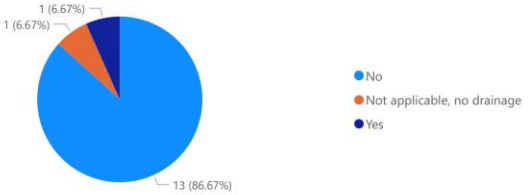
Hazard Preparation Measures



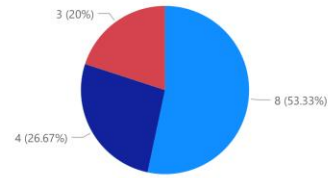
Hazard Reduction Measures



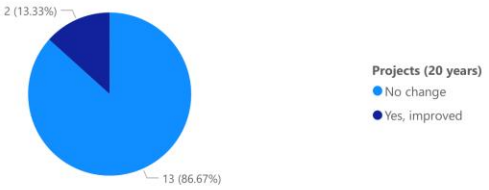
Drainage adequacy for heavy rainfall



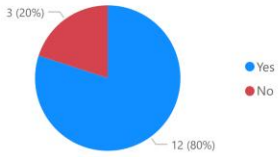
Project (5 years)



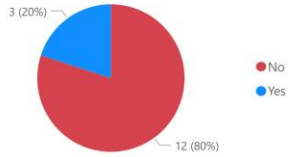
Projects (20 years)

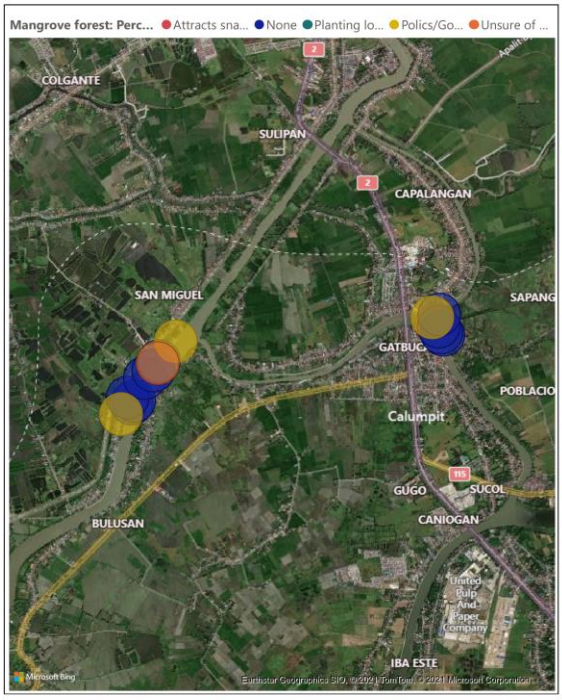


Government project awareness

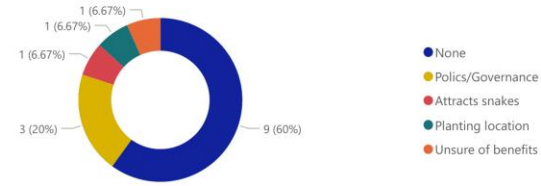


Willingness to relocate

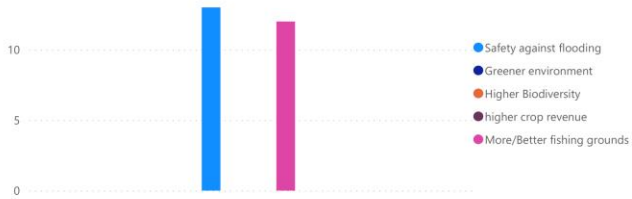


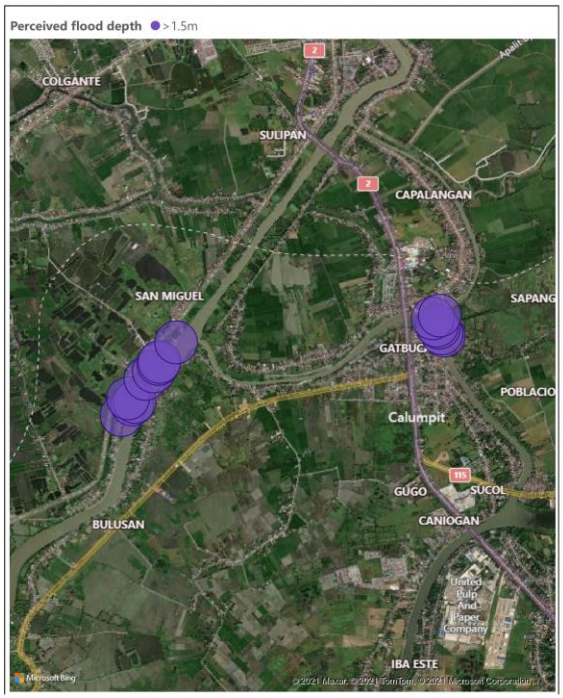


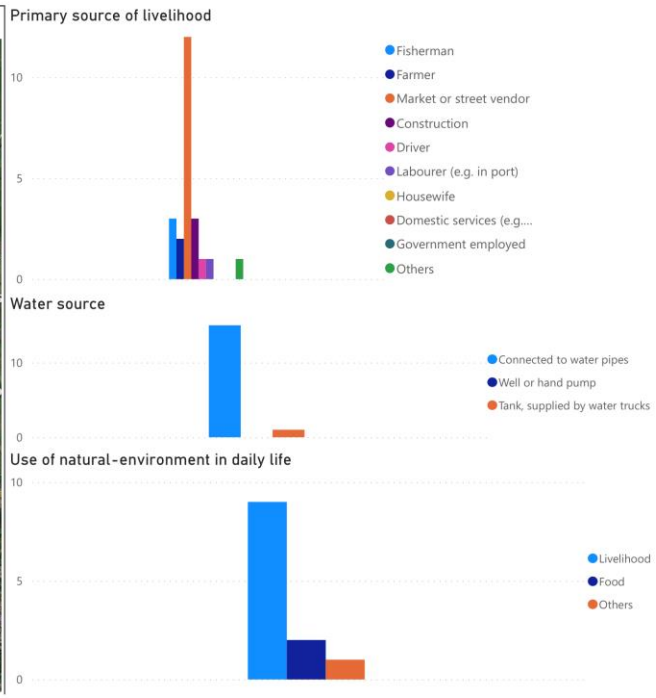
Mangrove forest: Perceived Disadvantages/Challenges



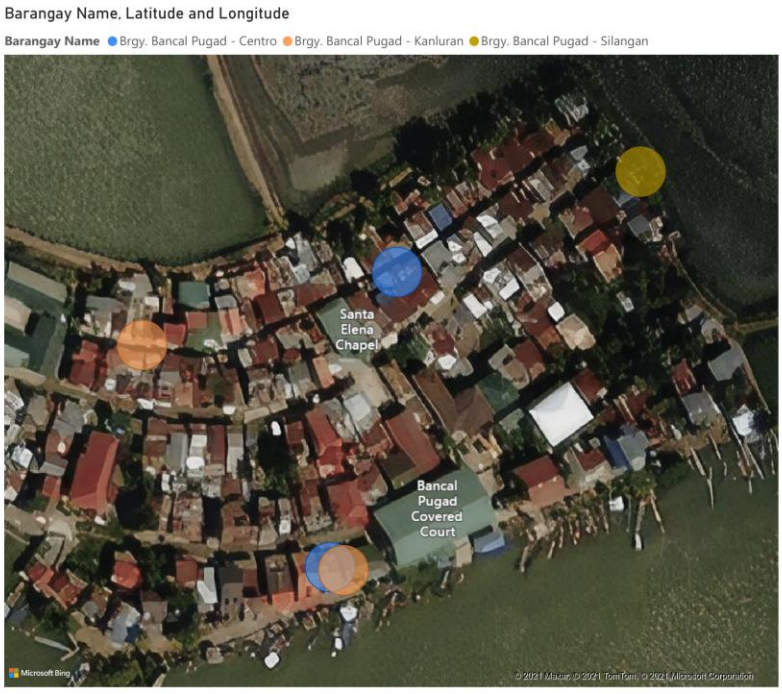
Perceived nature-based solution benefits

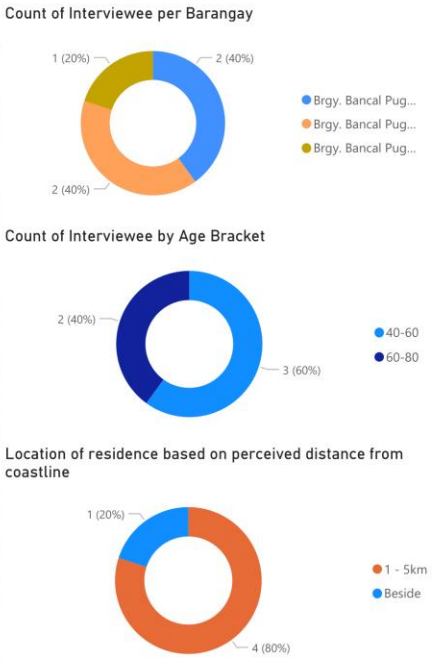


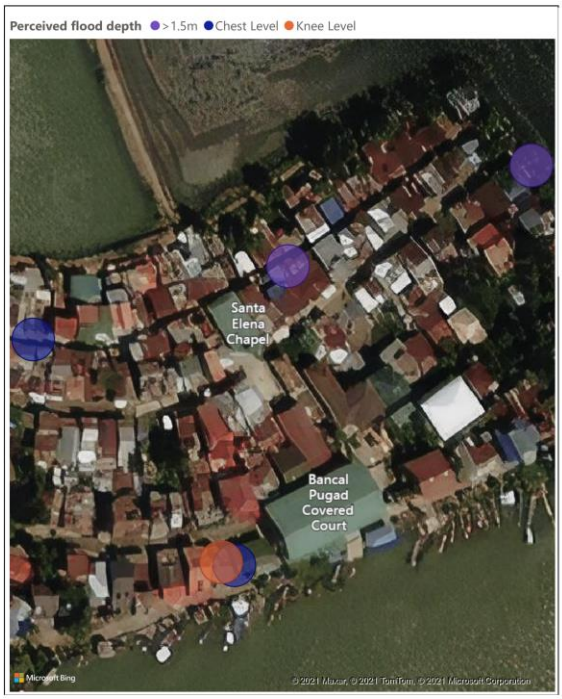




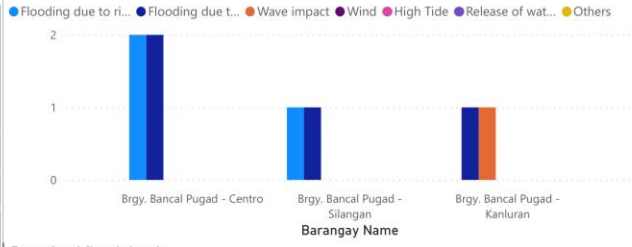
A.3.3.7 Lubao, Pampanga



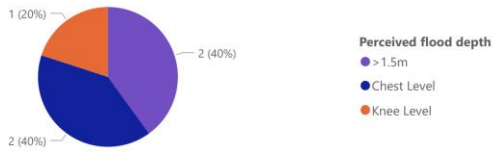




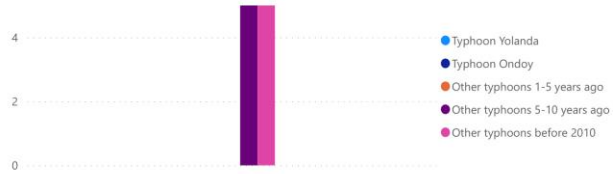
Perceived Coastal Hazard Source



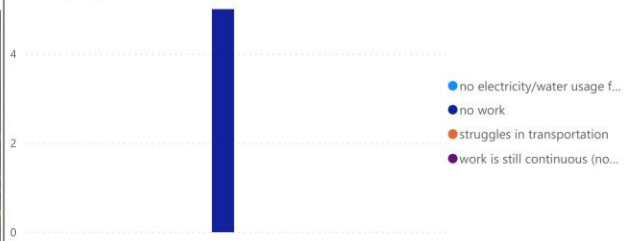
Perceived flood depth



Strongest typhoon experienced

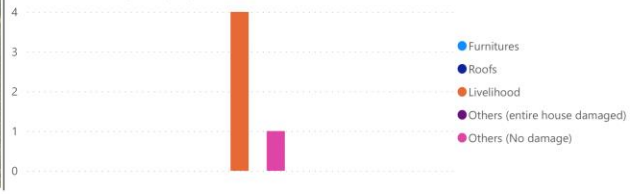


Flooding impact to livelihood

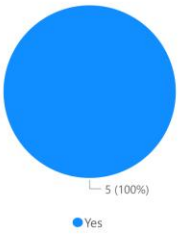


Perceived damage cost

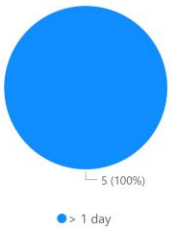
Perceived damage to properties



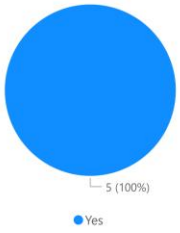
Barangay warning system availability



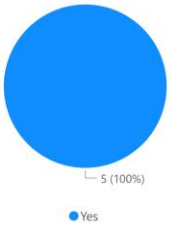
Warning lead time



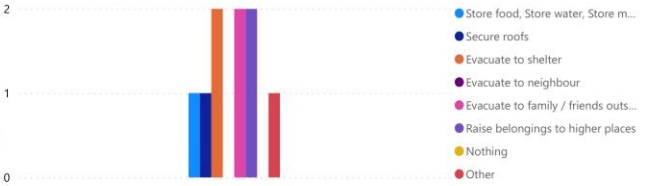
Safe access to shelter



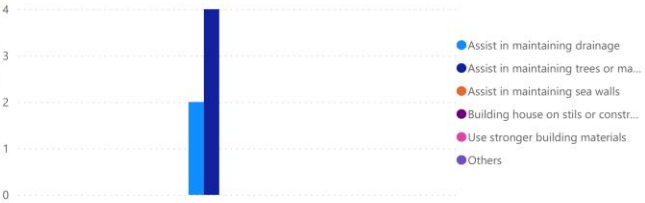
Access to transportation



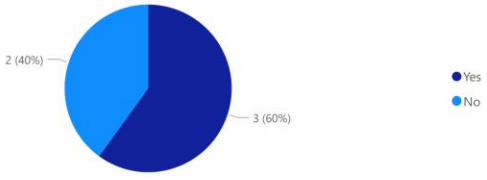
Hazard Preparation Measures



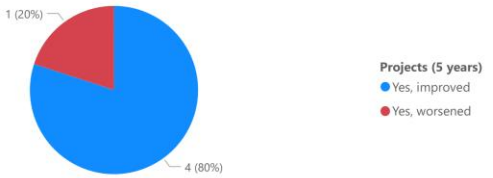
Hazard Reduction Measures



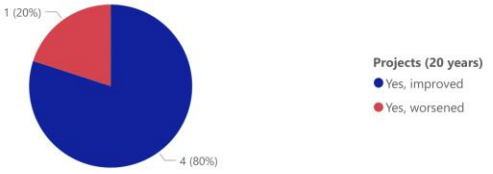
Drainage adequacy for heavy rainfall



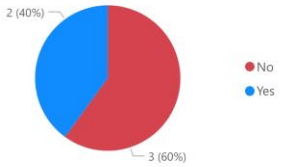
Project (5 years)



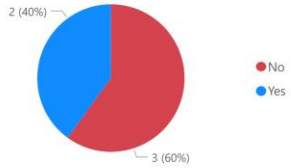
Projects (20 years)

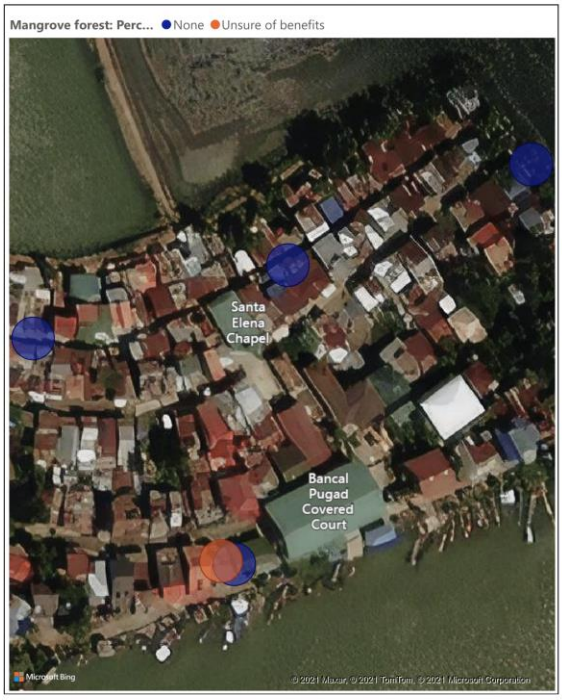


Government project awareness

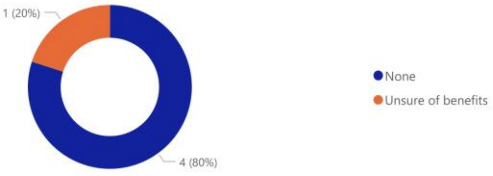


Willingness to relocate

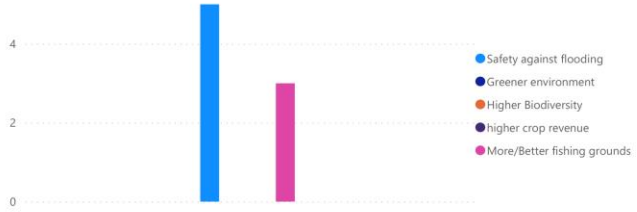




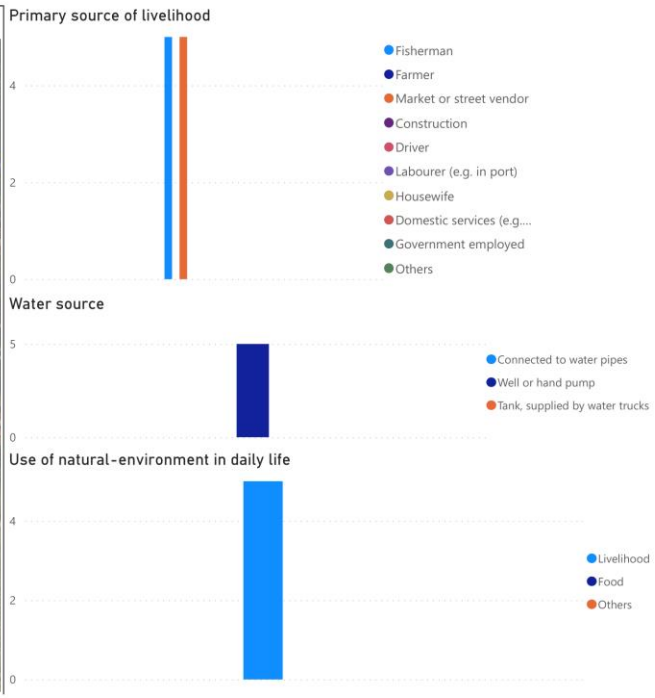
Mangrove forest: Perceived Disadvantages/Challenges



Perceived nature-based solution benefits




Perceived flood depth
>1.5m
Chest Level
Knee Level
Santa Elena Chapel
Bancal Pugad Covered Court
Microsoft Bing
© 2021 Maxar, © 2021 TomTom, © 2021 Microsoft Corporation


Primary source of livelihood
4
2
0
Fisherman
Farmer
Market or street vendor
Construction
Driver
Labourer (e.g. in port)
Housewife
Domestic services (e.g....
Government employed
Others
Water source
5
0
Connected to water pipes
Well or hand pump
Tank, supplied by water trucks
Use of natural-environment in daily life
4
2
0
Livelihood
Food
Others

Appendix 4

Appendix 4 Nature-based Solutions

Outline

1. Shellfish reefs

Description

(Artificial) Shellfish reefs can be used to dissipate wave energy. Implementation is possible by creating surfaces on which shellfish can attach. Shellfish reefs can grow (to a certain extend) with sea-level rise. Traditional solutions used instead of shellfish reefs are breakwaters and seawalls. Shellfish reefs have the following benefits:

- Dissipate wave energy and encourage sedimentation on the lee side
- Increase biodiversity
- Provide shelter for juvenile fish and serve as nursery grounds
- Oysters and mussels provide an attachment substrate for marine invertebrates and plants.
- Shellfish filter seawater. This improves water quality and visibility, benefitting visual hunters such as terns and predatory fish.
- Shellfish reefs contribute to natural coastal protection.
- Shellfish remove suspended sediments and algae from the water and deposit this material around their shells.
- The shellfish from the (artificial) reef can be used as a source of food

Figure 1: Reef created with four rows of oyster balls [1]

Figure 2: Oyster shell cages being used for erosion control [2]

Implementation North Manila Bay

Specifically, for North Manila Bay, shellfish reefs provide a solution to combat localized erosion and to increase shellfish production yields at the same time. They can contribute to some sediment trapping and overall water quality in North Manila Bay in the longer term. The implementation is expected to be easy as shellfish reefs can be constructed on a small scale (fewer stakeholders need to be involved), and adverse effects are limited. It is important that the shellfish reefs' production can be kept local, offering business opportunities within the area. Shellfish reefs can have a (local) positive effect on society as local people benefit from the business activities. A risk could be the impact of the pollution caused by chemicals used in the fishponds (usually done by the bigger fishpond owners).

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2. Enhanced breakwaters

Description

Breakwaters protect coastlines or structures against wave attack and subsequently reduce erosion. Traditionally breakwaters are made from armour rock and concrete materials. Flora and fauna can't adhere easily to smooth concrete and rock surfaces. Therefore, traditional breakwaters are not a good substrate to improve biodiversity. By minor changes in shape, material type and texture of conventional breakwaters, new habitats for flora and fauna can be created supporting biodiversity. For example, holes can provide additional shelter for crabs, and rough surfaces offer substrate for shellfish to attach. Also, the use of environmentally more suitable types of concrete and coastal protection elements with a "tidal pool" effect can positively impact biodiversity.

Figure 3: Rock armour roughness creation

Figure 4: Eco concrete tidal pools [3]

Implementation North Manila Bay

Breakwaters protect the North Manila Bay coast or population centres against wave attacks and subsequent erosion. They can also protect fishing boats (Banka's). Breakwaters can be used to preserve livelihood locally from erosion. Due to their permeable nature, breakwaters are not suited to prevent flooding. When building breakwaters in North Manila Bay, soft soil conditions need to be considered. Ground improvement underneath the breakwaters is most likely required, making constructing it relatively expensive. The construction of breakwaters has a negative impact on the environment, especially when they are built at ecologically valuable locations such as mudflats. The negative impact can be reduced by reusing materials and by creating additional habitats (see description above). The implementation is expected to be relatively easy as breakwaters can be constructed on a small scale (fewer stakeholders need to be involved). Breakwaters can benefit society as they can provide additional spawning areas for fish and shellfish, crabs, etc., but the impact is relatively small.

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3. Double dike system

Description

A double dike system consists of two dikes with a wetland (for example, a tidal flat area or wetland along a river) in between. Inlets in the outer dike are needed so that water and sediment can enter the area between the dikes (either during high tide or during periods with high river discharge). This promotes sedimentation. Due to this mechanism, tidal flats can grow with sea level. The double dike system along the coast can protect the coast from storm surges and contributes to tidal flat restoration. A double dike system along a river can protect the land from river flooding and restore wetlands.
The wetlands between the dikes can be used for aquaculture,habitat restoration or both.

Figure 5: Baras Catanduanes

Figure 6: Double dike in the Netherlands [4]

Implementation North Manila Bay

The current layout of North Manila Bay already includes some small-scale double dike systems by the presence of multiple fishponds. The difference being that the fishpond perimeters (small levees) have not been set up with the idea of providing flood protection for a bigger area than the fishpond itself.
The double dike system protects the area behind the inner dike against coastal/river flooding. In the coastal zone the two dikes limit wave attack in the area between and behind the dike. In the coastal zone, a double dike should be built so that river water can easily flow towards the sea to prevent an increase in river flooding. A double dike system can protect livelihood behind the dikes by reducing flooding and wave attack. Construction of dikes generally has a negative impact on the environment, especially when they are built at ecologically valuable locations such as tidal flats. However, the double dike system can be used to restore tidal flat areas on a large scale, hence the positive score on environmental impact. The institutional complexity of a double dike system may not be large as it already partly exists in Manila Bay, by the presence of a lot of fishponds. However, many stakeholders need to be involved in upgrading existing fishponds peterimeters into a double dike system, and good long-term maintenance arrangements are necessary. A double dike system positively affects society by protecting livelihoods, and the tidal flat restoration can contribute to economic activities such as fishing. The area between the dikes can also be used for aquaculture improving livelihoods.

Scoring

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4. Sediment transfer (reuse of dredged material)

Description

Dredging is essential for the maintenance and development of waterways and harbours. Dredging is also necessary for navigation, remediation, and flood protection. Dredged material can be a valuable resource. Coarse material (sand) is already widely used as a resource for construction. Soft material (mud) can be reused cost-effectively, for instance, by creating natural areas or parks with the sediment or by using it to counteract soil subsidence. Dredged sediments can also be used for wetlands restoration. Reusing dredged materials can benefit in two ways for projects: developers/agencies can cut down on disposal costs and at the same time use the material as an alternative source for sand. For instance, if a harbour is dredged and a nearby beach needs replenishment, the newly retrieved sediment may be suitable for beach nourishment and coastal protection. Not all dredged material is suitable as a resource, but in some countries, like Japan, more than 90 percent of dredged material is ultimately put to good use. This may require treatment of the sediments, but generally speaking, dredged material such as rock, gravel and sand, consolidated clay, silt or soft clay and a mixture of rock, can, to varying degrees, be used as a resource.

Figure 7: Reuse of dredged material [5]

Figure 8: Reuse of dredged material [6]

Implementation North Manila Bay

Dredging activities in the North of Manila Bay area can be divided in river dredging and sediment mining on the Manila Bay seabed. Currently, several ongoing schemes focus on river dredging to enhance the rivers runoff capacity. Significant amounts of sediment dredging for ground improvement works and navigations purposes for the ongoing reclamation projects and shipping channels will be done in 2022 and 2023. DENR permits are currently focused on depositing the dredged soils outside of Manila Bay. Two quick wins will be:

1. Repurpose the dredged materials from the rivers to enhance eroded embankments and to use it as source material for the Coastal Line of Defence
2. Use the dredged materials from the reclamation projects/mining concessions to restore mudflats and mangrove areas.

Both solutions will positively affect flood and erosion impacts for most of the areas in the North Manila Bay area. Both solutions also have a positive effect on restoring lost habitats. The areas that are enhanced with the reused dredged materials will offer new lands for aquaculture, which has a positive social impact. Due to the size of the projects and the number of authorities/parties involved this solution is complex in terms of the institutional setting.

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5. Mangrove rehabilitation

Description

Mangrove forests are one of the most severely threatened and undervalued ecosystems on Earth. For many coastal communities, mangrove ecosystems provide livelihoods, essential food sources, and coastal protection. Mangroves are being cleared at an alarming rate, and there are numerous threats to these forests, including land development, pollution, deforestation for fuel and climate change. One of the major reasons for the loss of mangroves has been the establishment of fishponds for aquaculture. The North Manila Bay area is an example of such developments.

In the North Manila Bay area, about 90% of the original mangrove forest have been lost in the past century. Awareness and urgencies of restoring lost mangrove forests in the Philippines are growing, resulting in various planting/rehabilitation efforts. Most approaches to mangrove restoration were based on planting a forest on land by growing mangrove seedlings in greenhouses and subsequently transplanting them into mudflats along the ocean's edge. This approach has met mixed results in the Philippines. Mangrove systems are very complex and require stringent conditions regarding seabed gradient, salinity, substrate type. For the North of Manila Bay this translates into a requirement on focussing on rehabilitation-only in areas where mangroves used to grow by natural growth, and not to force plantation on former mudflats or other non-suitable areas.

Figure 9: Mangroves in the Philippines [7]

Figure 10: Mangroves in the Philippines [8]

Implementation in North Manila Bay

The Building with Nature Asia landscape proposition for North Manila Bay suggests restoring a part of the original mangrove forest within the current fishpond areas. This interlinked area is defined as a Mangrove Belt. Specifically for flood protection, the mangrove belt dampens wave energy, reduces flow velocity, and reduces wave attack and coastal flooding. Due to a reduction of wave attack, the risk of dike breaches behind the mangrove belt is much lower, reducing coastal flooding even further. The mangrove belt protects this way livelihoods. The mangrove belt should be created so that it does not hamper the flow of river water towards the sea. Otherwise, it can cause increased river flooding. The creation of smaller mangrove restoration projects is generally accepted in the Philippines and is not seen as complex. However if implemented on large scale it becomes more complex, there will be negative effects for stakeholders: housing or aquaculture may need to be removed at some locations. The zonation, which combines economic activities with mangroves, is very important. If a mangrove zone is created in the right way with the right balance between ecosystem restoration, coastal protection, and economic activities, it will positively impact society.

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6. Wide green dike

Description

A dike is a barrier to regulate or hold back water from a river, lake, or ocean. In the Philippines, dikes are mainly used for preventing river flooding. A typical dike in the Philippines is designed according to the DPWH design standards Volume 3 (Water Engineering), and is focused on preventing flooding when river water levels rise due to increased rainfall runoff. These typical dikes have relatively steep slopes to avoid taking up too much space on the river banks. Due to this, the dikes are more prone to erosion (due to decreased stability), which subsequently requires “hard” revetment structures, which negatively impact natural habitats.

A wide green dike seeks to transfer the “traditionally steep-sloped dikes” into a dike with a much bigger footprint and gentler slopes. Due to this, the use for “hard” revetment reduces, and the dike can be used as a multipurpose area, including but not limited to: habitat restoration and roads/traffic. Furthermore, a wider dike is much more robust in light of climate change as there is a wider area for future reinforcement available. The dike could be constructed reusing dredged materials.

Figure 11: Wide green dike [9]

Figure 12: Wide green dike [10]

Implementation in North Manila Bay

A wide green dike effectively reduces both coastal and river flooding if it is well maintained. A sole earthen dike cannot withstand large waves; hence other measures are needed to reduce wave impact (mangroves in front of the dike or a stone reinforcement at the lower part of the dike). A dike is suitable as the last line of defence to protect towns but is not suitable for protecting livelihood at the tidal flats. The construction of an earthen dike generally harms the environment, especially when they are built at ecologically valuable locations. The negative impact can be reduced by reusing materials or constructing the dike in areas with no ecological value (roads, developed lands). The institutional complexity of dike construction depends on the scale. The clear positive effect on the protection of towns makes implementation easier. Good long-term maintenance arrangements are necessary because otherwise, the flood risk can become very large in the future. An earthen dike positively impacts society due to the protection against flooding.
The wide green dike is a feasible solution for implementing the Coastal Line of Defence. In that case, it could be implemented with multiple uses (habitat restoration, road network and livelihood creation).

						
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7. Hanging and floating structures

Description

Farming techniques using ropes hung vertically under floating rafts that support mussels and/or algae. The success of this measure will depend on a source of individuals to colonize the ropes. Although it may be possible to bring in species it is very important to determine whether those species do occur within the surrounding area and would not pose a threat to the native species as this can have significant effects on the local biodiversity and people's livelihoods, who rely on other marine activities.

There is also the potential for growing and harvesting other bivalve molluscs species in bags within the shallow subtidal areas. Several methods could be examined, including single drop farming and rope or raft culture. The single-drop farming technique uses drops (similar to socks). The drops are filled with mussel spat, which then grows inside the sock, eventually moving outside as they increase in size. The mussels are then harvested when they reach the required size. The rope and raft culture act in a similar way but the mussels are suspended from a raft floating on the surface of the sea.

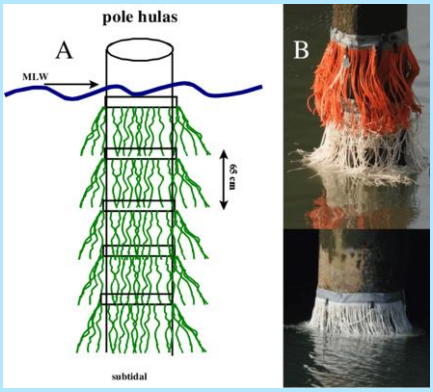

Figure 13: Pole hulas [11]

Figure 14: Aquaculture floating structure in North Manila Bay

Implementation in North Manila Bay

Using hanging and floating structures is familiar in the North of Manila Bay, though it is implemented on a small scale. Hanging and floating structures have no impact on coastal and river flooding but can be used to reduce wave attack. Hanging and floating structures have a beneficial effect on biodiversity as they offer additional habitats for shellfish. Hanging and floating structures can be easily implemented as they are a small-scale (fewer stakeholders involved), relatively cheap design solution with limited negative effects. The structures can have a beneficial impact on society as shellfish can be harvested.

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8. Tidal flat restoration

Description

A tidal flat is defined as a flat area or stretch of land consisting of sandy or muddy sediments exposed at ebb tides. Tidal flats serve a variety of environmental functions, including habitats, water purification, biological productivity, and water accessibility. These functions are supported by diverse environmental conditions distinctive to the topographic features and locations of tidal flats, together with the biological activity of marine organisms living there. When restoring tidal flats, various physical and environmental requirements need to be considered in the design.

Tidal flats can be restored by manually placing (dredged) sediments to elevate/equalize the area in order to create the right gradients. This will force the creation of the tidal flat, which might not be “equal” to the natural sediment balance. The risk is that this situation is not balanced and will need maintenance in order to keep the tidal flat in existence.

A better way of restoring tidal flats is to intervene/create sediment trapping/feeding solutions. Sediment trapping can for example, be increased by creating shelter with groynes/brushwood dams. The sediment supply can be increased by allowing rivers to dump the sediment on the tidal flats by reverting river constraints (like dikes or dams). Tidal flats can break waves and can grow with sea-level rise. On top of that tidal flats are an important food source for birds and provide shells, crabs etc.

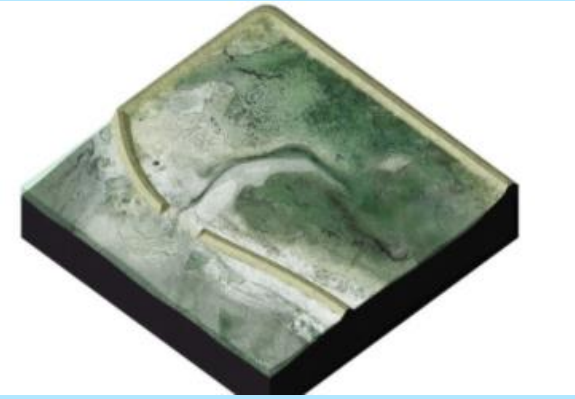

Figure 15: Breakwater trapping tidal flat restoration [12]

Figure 16: Tidal flat with free sediment disposal [13]

Implementation in North Manila Bay

Restoration of tidal flats can on the long term, contribute to flood protection as tidal flats can grow with sea-level rise, due to the ongoing feed of sediments coming from the river. The problem in the North of Manila Bay is that all the rivers have diked embankments on places where the rivers used to have an “undisturbed outflow”. This results in the sediments from the rivers being directly transported into Manila Bay with no chance the deposit on the tidal flats (which have been replaced by fishponds). Tidal flats can contribute strongly to a decrease in wave attack when they are wide. Tidal flat restoration strongly contributes to the environment as valuable habitat is restored and biodiversity is increased. Restoring tidal flats can be intuitionally complex as multiple stakeholders are involved and as the space needed for tidal flat restoration is currently used as fishponds. There might be a negative impact on the livelihood of fishermen as the tidal flats will not yield as much aquaculture as the current fishponds. It does open up tourism possibilities for the livelihood component.

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9. Adaptive housing (program)

Description

If the choice is made to build or to maintain buildings in flood risk areas, there are various ways to create adaptive housing. With adaptive housing, an amount of flooding is accepted usually because taking (big and costly) system measures are too expensive and do not justify the expenses of the areas they are protecting. Adaptive housing can be divided into 3 types: Stilts, Floating and Water Proofing.

Stilted structures are better to be constructed in areas without many wave attacks as wave forces can damage the stilts and pose a threat to the people living in the houses. To mitigate this, breakwaters or mangrove areas can be added as protection.
Floating houses can be a different solution. These are usually more expensive than stilted houses as the floating houses need moving components (mooring, utilities) to be maintained.
Making houses flood proof can be done by lining the first floor of a house, or only using the first floor as parking space as examples.

Figure 17: Adaptive housing Vietnam [14]

Figure 18: Paombong adaptive housing

Implementation in North Manila Bay

Adaptive housing can already be seen thought out the North of Manila Bay, where houses are placed on stilts. This is mainly done for the coastal communities very close to the current coastline. Stilt-build houses do not reduce coastal/river flooding or wave attack but are very effective in protecting (individual) properties. Stilt-build houses instead of traditional housing have little negative or positive impact on the environment. Building houses itself generally has a negative impact on the environment. By adaptations, for example reuse of materials and building floating houses (space for nature below the house), negative impacts can be reduced. The institutional complexity regarding subsidized stilt-build houses is expected to be relatively complex, as regulating adaptive housing will require individual funds to be approved. Adaptive housing has a positive social impact as properties are protected but has not many additional benefits.

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10. Room for rivers

Description

Room for the rivers, in its essence, is to restore the river flow of the original river. It means increasing space for the water to flow (controlled flooding) to reduce flooding in other (economically valuable) areas. The original “footprint” of rivers worldwide has been under pressure from urbanization for a long time. This led to smaller river widths, resulting in flooding problems upstream of these locations. The peak flood elevation becomes lower upstream, with a larger space for the water to flow during peak discharge. This reduces the risk of dike breaches and the risk of flooding in general.

Different measures are possible to create room for the rivers. These measures include the relocation of river dikes more inland, the removal of obstacles (for example trees and buildings that stand in the way of the water flow during peak discharge) and expropriation of fishponds segments located in critical water flow areas, creating natural embankments and constructing flood diversion channels (secondary channels).

Figure 19: Room for the Rivers concept [15]

Figure 20: Room for the River project in Nijmegen (NL) [16]

Implementation in North Manila Bay

The narrowing of rivers and flood plains due to dikes and fishponds is one of the major reasons for the flooding issues in North Manila Bay. In recent decades the major rivers have been constrained by building dikes all the way up and beyond the original river outflows. This transformed a once-dynamic river delta into a much more static system, which cannot cope with big environmental changes in the short term (rainfall, tides, storms) and in the long term (climate change, land subsidence).

Creating room for the river on the North Manila Bay Delta will significantly reduce river flooding but has no effect on coastal flooding and reducing wave attack. Reducing river flooding will lead to enhancing the protection of properties, but some properties may need to be removed to create space for the water to flow near the river channels. It has been observed that settlers usually occupy the riverbanks (dikes). The relocation of these settlers/inhabitants might have a negative impact on their livelihood.

Creating room for the rivers restores the river system to a more natural state and has a beneficial impact on the environment. Creating room for the river has a beneficial effect on society as properties are protected, and nature is restored leading to a more sustainable system, but will be hard to implement on a bigger scale. The plans are constitutionally complex because sacrifices (relocation, buying up land) in some areas are needed to protect the other regions. Also, many stakeholders are involved.

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11. Retention basins

Description

A retention basin is an artificially created area used to manage/divert/temporarily store water entering a system. To reduce the influx of rainwater into a river system, a retention basin can be created upstream to store the water. These retention basins are not used frequently (once or twice a year). The rest of the year, the retention basin can be used for agricultural purposes or other land uses that allow for flooding without too much damage. The stored water can be used as a source of freshwater, reducing the need for groundwater extraction leading to less land subsidence.

Retention basins in rivers basin can “cap” a certain amount of flooding downstream and are suited to mitigate frequent flooding events. For more severe flood events (once every 10 years), large retention basins are needed, which are harder to implement. On a large scale creating wetlands in coastal areas can also act as a retention basin for flood/surges coming from the sea.

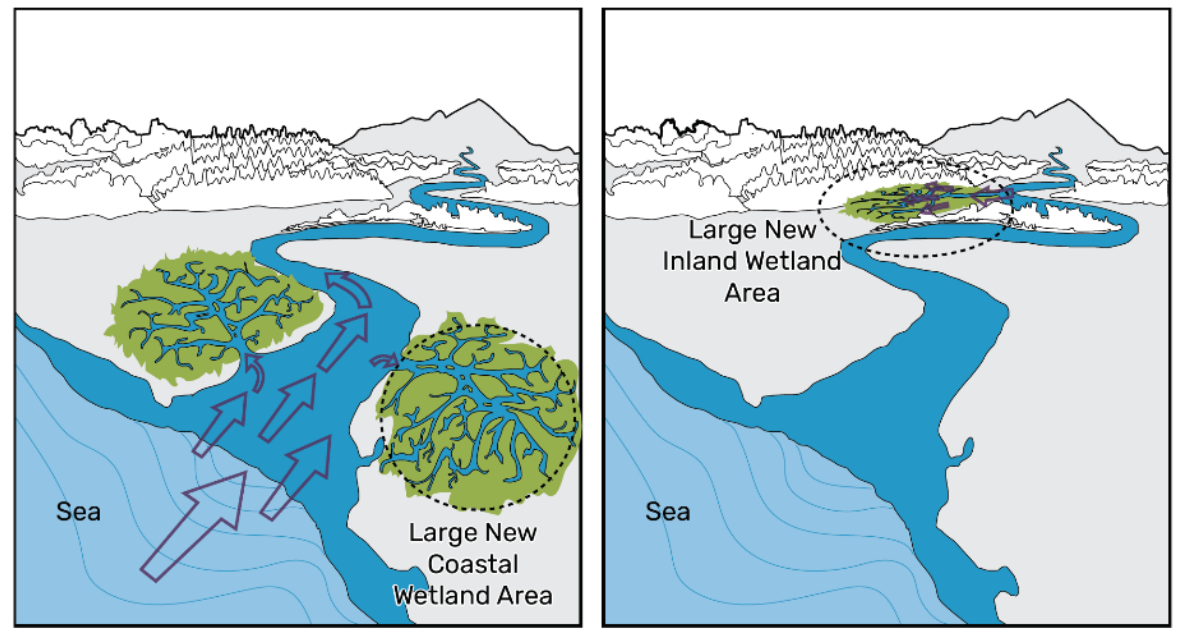

Figure 21: Retention basins [17]

Implementation in North Manila Bay

Retention basins upstream of the rivers will significantly decrease river and compound (combination of storm surge and large river discharge) flooding but do not reduce wave attack.
By reducing river and compound flooding, the measures will lead to the protection of properties; however at the locations where the basins/wetlands are created some properties may need to be removed to create space for the water. Wetlands in the basins contribute to biodiversity and, therefore, can benefit the environment. Creating wetland areas and retentions basins can be constitutionally complex because sacrifices in some areas may be needed to protect other areas. Also, many stakeholders are involved. All in all, the retention basins and mainly the wetlands benefit society as properties are protected, and nature is restored, leading to a more sustainable system. Given the problems of North Manila Bay with land subsidence, this solution provides excellent synergy with mitigating groundwater extraction.

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12. Green embankments

Description

Creating a green zone with mangroves between the river and adjacent ponds by catering for or planting mangroves along denuded riverbanks will lead to an increased protection level against erosion of the riverbanks. Due to the growth of vegetation, the riverbanks are maintained and protected against erosion as the vegetation “fixates” the soil. Mangrove trees catch sediment so that sedimentation in ponds adjacent to the river is limited. By a smart combination of the mangrove zone, more diversity in aquaculture can be developed with benefits for the economy. The point of attention is that the mangrove zone should not extend towards the channel as this would result in less 'room for the river' and an associated increase in river flooding.

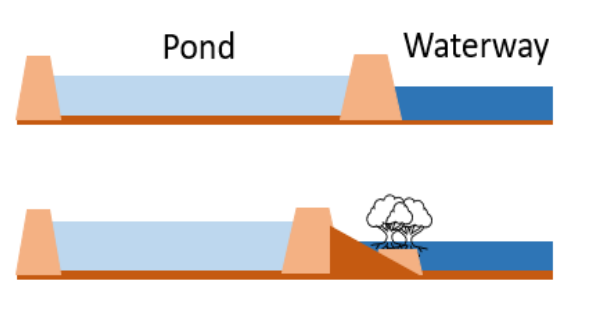

Figure 22: Creating space on embankments [18]

Figure 23: Catanduanes comparison

Implementation in North Manila Bay

Creating green embankments decreases river flooding but has no impact on coastal flooding. It is particularly efficient in protecting against erosion. In the North Manila Bay area, many dikes/ponds are lined with concrete revetment as the revetments are prone to failure/erosion due to the soft soil conditions. The green embankment protects properties from flooding up to a certain extent at areas where ponds are very close to the river channel. Green embankments contribute to biodiversity and therefore have a beneficial effect on the environment. The solutions are relatively easy to implement if the extra space needed can be found in the embankments' current footprint. The green embankments can benefit society because the trees can be used to filter water so that aquaculture can be more diverse.

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13. Rainwater collection and storage at buildings

Description

Rainwater harvesting collects the runoff from a structure or other impervious surface to store it for later use. Traditionally, this involves harvesting the rain from a roof. The rain will collect in gutters that channel the water into downspouts and then into some sort of storage vessel. Rainwater collection systems can be as simple as collecting rain in a rain barrel or as elaborate as harvesting rainwater into large cisterns to supply one or multiple household demands.

Rainwater harvesting will positively influence the alternate modes of freshwater collection (groundwater, for instance). Clusters of rainwater harvesting solutions have multiple benefits in supplemental irrigation, inland fish production, and water for domestic and livestock production. They also serve as strategic small-scale upland structures that enhance groundwater recharging, prevent flooding, and provide value-adding activities such as recreation, soil and water conservation, and environmental benefits.

Figure 24: Rainwater collector [19]

Figure 25:Rainsaver tank [20]

Implementation in North Manila Bay

Collection and storage of rainwater at buildings reduces the amount of runoff during heavy rainfall. If implemented on a large scale, this can reduce urban flooding and associated damage to properties to a small extent. Collection of rainwater may lead to reduced river discharge and flooding, but small-scale measures in urban areas are expected to have no significant effect on river flooding. Rainwater collection reduces the pressure on the aquifer which is beneficial for the environment. Rainwater collection measures can be easily implemented. Both small-scale and large-scale investments are possible and negative effects are limited. All in all, the measures have a beneficial impact on society.

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14. Climate and water resilience planning CLUP updates

Description

The Comprehensive Land Use Plan is an instrument for the local government unit to allocate available land resources to different sectors of its territory for different functions. The Comprehensive Land Use Plan allows the local government unit to communicate to various sectors of the population how it plans to cater to their needs of land resources. A CLUP is mandated by the Local Government Code (Republic Act 7160) that local government units in the Philippines must prepare.

Being the Chief Executive, the mayor is the key official for ensuring that Comprehensive Land Use Plans are formulated and updated regularly. Usually, the Local Planning and Development Office (LPDO) of an LGU sets up and maintains the CLUP. Including space/areas for climate and water resilience (and the Nature-based Solutions proposed in this strategy) is pivotal for the execution of any flood-related projects.

Figure 26: 3rd DENR CALABARZON PENRO CENRO

Figure 27: Calumpit stakeholder meeting

Implementation in North Manila Bay

Improving water and biodiversity management planning will lead to more effective and sustainable development of the coast. With proper land-use planning, coastal and river flooding and wave attacks can be reduced and better protected properties. Measures can be chosen that have a beneficial impact on the environment and society. Some measures for sustainable use of the delta/coast will negatively affect individuals (for example, removal of properties to create space for the water). Climate and resilience planning in CLUP updates can be institutionally complex as many stakeholders have conflicting wishes. Enforcing the policies may also be difficult as the land-use plan may negatively impact individual stakeholders.

						
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15. Increase sediment loading on the coastline

Description

Natural accretion of sediment is important for coastal protection. There are many solutions for increasing sediment supply in the coastal zone and reducing the loss of sediment in the coastal zone. For example, tidal flats and mangrove forests need continuous sediment supply to maintain themselves and to be able to grow with sea level rise. Some of the measures shown in this flood protection strategy already contribute to increasing the sediment loading along the coastline.

Specific measures that can be taken to increase the sediment loading are for example creating brushwood groynes or large scale oyster beds.

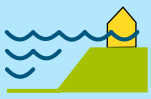
Figure 28: Brushwood groyne [21]

Figure 29: Oyster beds [22]

Implementation in North Manila Bay

Increasing the sediment load along the coastline is a long-term solution so that the coast can keep up with sea-level rise (to a certain extend). In the short term, positive effects may be limited, but in the long term, these measures are very important for the sustainable long-term development of the North of Manila Bay.

As the coast can grow with sea level rise, these measures reduce coastal flooding and wave attack and protect livelihood in the long term. The measures have less impact on river flooding (as the measures presented here are focused on increasing sediment loading along the coastline). The example solutions contribute to the environment as they all contribute to restoring the system to a more natural state. The measures may be difficult to implement and enforce because certain stakeholders will be negatively affected. However, implementation does not require large construction works or drastic landscape changes with huge impact for landowners, making it easier than other measures. In the short term, the impact on society may be small or negative, while society benefits from sustainable coastal protection on the long-term.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16. Prevent/regulate sediment extraction

Description

Seabed based sediments are a source of construction materials. The worldwide volume being extracted is having a major impact on rivers, deltas and coastal and marine ecosystems, sand mining results in loss of land through coastal erosion, lowering of the water table and decreases in the amount of sediment supply. Extraction has an impact on biodiversity, water turbidity, water table levels, landscape and climate.

Institutional/policies/awareness measures include a moratorium against activities that cause a decrease in sediment loading along the coastline and/or incentives for beneficial use of sediment. Specific examples include a moratorium against:

- Sediment mining and dredging along the coastline;
- Dredging at river mouths.

Implementation in North Manila Bay

As can be seen in the main flood protection strategy report, various seabed mining concessions have been issued along the coastline in the North Manila Bay area. First, these concessions need to be reviewed and checked against their impact on the environment. By either adjusting the mining areas or preventing mining in areas where mining has a negative impact on coastal accretion, flood risks in the North Manila Bay area can be reduced. This might be difficult to implement as the quarry permits already have been issued. A middle way could be discussing with the quarry permits owners what they will do with any overburden they will dredge (silt) and not use as mining output. These overburden sediments could be used for coastal mudflat restoration.

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17. Instigate, Maintain and Protect Nature-based Solution areas

Description

When executed correctly the Nature-based Solutions should have the potential to be self-maintaining over time. For example, with sufficient sediment supply, mangroves and marsh features may accrete vertically with sea-level rise. But without a legal framework that protects the areas in which the Nature-based Solutions are applied, and without an active monitoring and maintenance plan for the first 10 years the feasibility of the Nature-based Solutions will be put under pressure.

The institutional context has a significant role in the feasibility and success of Nature-based Solutions. Jurisdiction and permitting requirements are the basis of successful implementing Nature-based Solutions. This requires institutional awareness and knowledge about the long-term effects /development of the area, and why Nature-based Solutions are a key to solving flood risks in the long term.

Safeguard mechanisms in policy implementing rules and regulations to avoid development in critical wetlands and biodiversity areas as part of CCA should be strengthened. The protection of these areas contributes to protection against coastal flooding and food security for communities.

Figure 30: Mudflats North Manila Bay [23]

Implementation in North Manila Bay

This flood protection strategy assumes that a large part of instigating, maintaining, and protecting Nature-based Solution areas will be covered by the Manila Bay Sustainable Development Masterplan. Nevertheless, if this flood protection strategy is implemented without the Masterplan being in place, this solution/action is pivotal.

Anchoring the importance of sediments, mudflats and coastal forest/mangroves in the legal/institutional context will lead to a much more feasible implementation of large-scale flood protection schemes driven by Nature-based Solutions. It will ease funding possibilities and will increase the mandate of regional and local governments to execute projects. It will be intuitionally complex for example the current (national/regional) Integrated Coastal Zone Management efforts are not seen connecting with CLUP (local) zoning plans of the LGU. Also, increasing the importance of coastal areas/lands will interface with commercial developments such as land reclamations and port constructions.

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18. Nature-based Solutions awareness

Description

The role of Nature-based Solutions in flood protection and tackling the climate challenge is being recognized more and more. However, further awareness is needed to let Nature-based Solutions compete with “traditional engineering solutions”.

Promoting Nature-based Solutions needs to be done for all three levels of government (national, regional and local). On top of that, it will need to form part of the education curriculum for the relevant education institutions. The goal is increased awareness and acceptance of NbS as a viable alternative to current flood mitigation practices.

Figure 31: Consultation Flood protection strategy

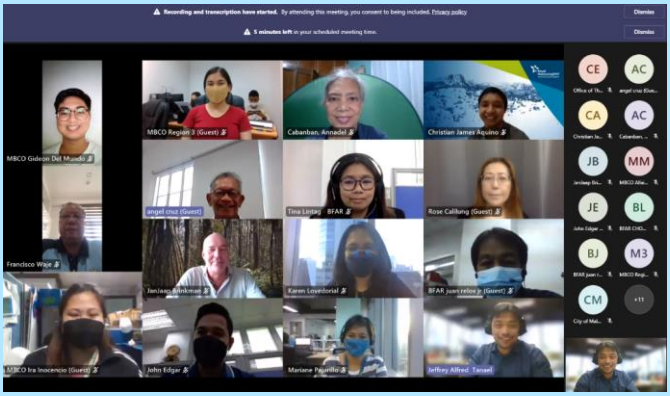

Figure 32: Screen capture NbS webinar

Implementation in North Manila Bay

As part of the North Manila Bay Flood Protection Strategy, various efforts have been undertaken to increase the awareness of Nature-based Solutions. Locally presentations were given to LGU/inhabitants, and webinars were held on a more regional/national level.

Creating awareness about integrated coastal and flood management measures built on nature-based approaches and best practices will help implement different NbS measures in the Manila Bay area. Thereby, it will help to reduce coastal and river flooding, wave attack, and associated loss of properties. Also, it will have a positive effect on the environment and society. Organizing individual dissemination events is relatively easy. Creating real understanding in a broad group of stakeholders will be more difficult.

						
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19. River diversion

Description

River diversions are commonly used to divert and distribute water from one river/basin to another. This way water upstream from, for example a urban populated area, can be divert before it can cause water levels to rise. Diversions will create a new channel on the delta floodplain from the diversion location to the other river or coast that tries to establish a depth and width in equilibrium with upstream sediment transport and water. The diversion could be prone to variable sedimentation due to backwater hydrodynamics. Diversion channels usually have sluice gates at the in- and outflow to manage the flow in the diversion.

The diversion could be combined with flood planes (which will require extra width) in which the flood planes could be used to restore natural habitat and provide extra robustness in terms of capacity. The figure below shows a “straightforward” diversion channel with no added Nature-based Solutions. When executed properly a more natural diversion could be labelled as Nature-based Solution. The idea has already been conceptualized by a Thesis study from A van ‘t Veld [24]

Figure 33: Example of river diversion in North Manila Bay

Implementation in North Manila Bay

A river diversion does not have any impact on preventing coastal induced flooding, it is however, very efficient to battle river flooding. This is only the case if the water is diverted to an area in which it has less impact or an area that is part of another catchment. If this is not the case it will only “offset” the problem to another area. By preventing the flooding in urbanized areas a lot of damage can be mitigated. When executed properly the impact on the environment can be minimalized. In the case of North Manila it could even have a positive impact if the diversion is being paired with habitat restoration. Creating a diversion channel is instutionally complex as it will span several LGU’s and even provinces. Also it can have an adverse impact on social wellbeing as fishponds/livelihood will need to be relocated.

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20. Update DPWH guidelines

Description

Department of Public Works and Highway (DPWH) has a set of existing design guidelines, among which Volume 3 Water Engineering Projects [25] and the Value engineering guidelines [26]. The Water engineering guidelines describe how river training and coastal protection work need to be designed from an engineering standpoint. The Value engineering guidelines layout basic principles on CAPEX and OPEX and how civil works can be designed most cost-effectively over their lifetime.

Nature-based Solutions can provide an excellent value engineering proposition and, in some cases, even better than traditional “grey” solutions. However, there are no existing guidelines available on the implementation of Nature-based Solutions and how they are competing with traditional engineering solutions.

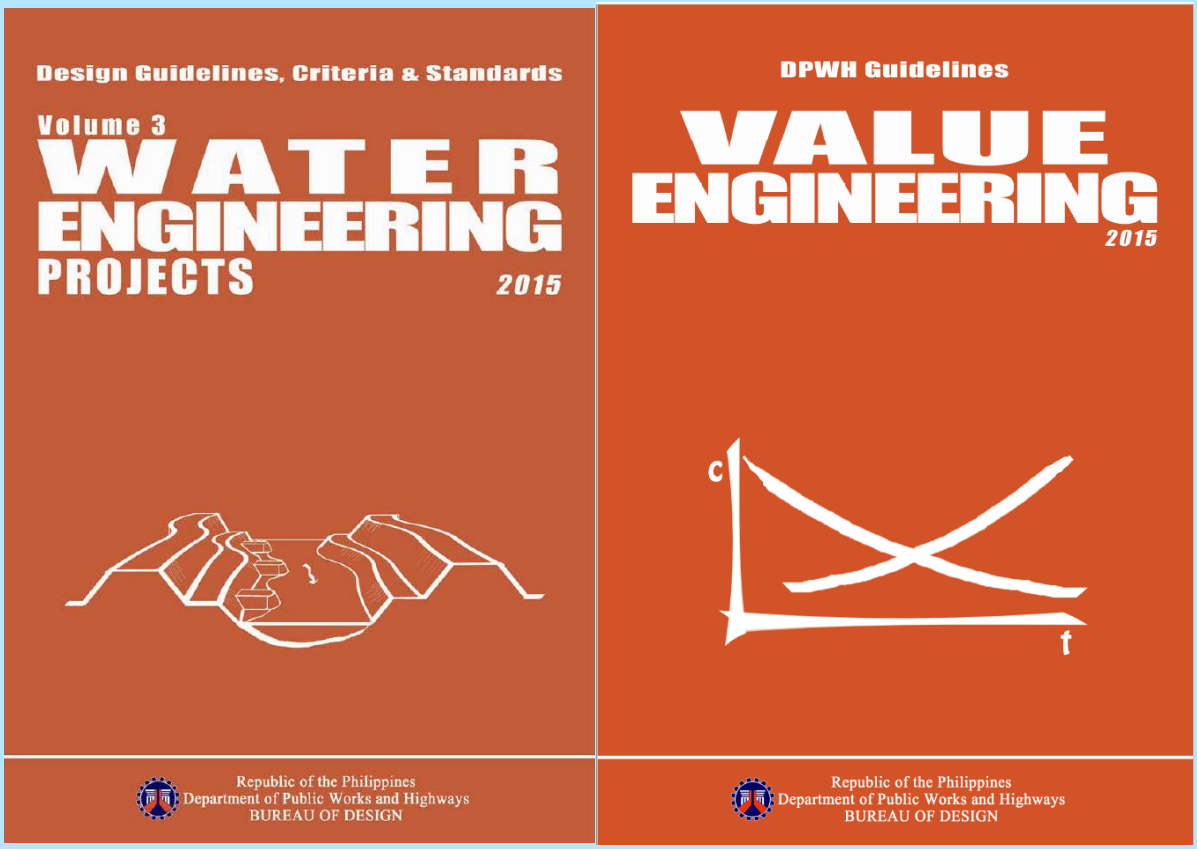

Figure 34: DPWH relevant guidelines

Implementation in North Manila Bay

Updating the DPWH engineering guidelines will positively impact the engineering solutions against river and coastal flooding. As the update will be focussed on Nature-based Solutions the environmental impact will also be beneficial. Furthermore, the institutions will be willing to help and open to the idea. There are not many direct social benefits from this solution.

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[1] The Reef Ball Foundation, “Oyster Reefs,” [Online]. Available: https://reefinnovations.com/services/ecosystem-restoration/oyster-reefs. [Accessed 16 12 2021].

[2] B. R. L. The Advocate, “Freedom Benefits,” 2009. [Online]. Available: https://www.freedombenefits.net/oyster-restoration.html.

[3] EcoConcrete, “ECOConcrete Shoreline protection,” [Online]. Available: https://econcretetech.com/applications/shoreline-protection/.

[4] N. C. f. R. Studies, “Double Dike,” [Online]. Available: https://kbase.ncr-web.org/all-risk/study-areas/double-dike/.

[5] M. Page, “Re-use of dredged material,” [Online]. Available: https://www.broads-authority.gov.uk/.

[6] A. Barrier, “What is Dredging in Construction?,” [Online]. Available: https://aquabarrier.com/blog/dredging/what-is-dredging-in-construction/.

[7] Wetlands International, “Building with Nature Asia landscape propostion Philippines,” 2021.

[8] ZSL, “ZSL Let's Work for Wildlife,” [Online]. Available: https://www.zsl.org/conservation/regions/asia/rehabilitating-mangroves-in-the-philippines.

[9] NCR, “Netherland Centre for River studies,” [Online]. Available: https://kbase.ncr-web.org/all-risk/study-areas/wide-green-dike/.

[10] W. Window. [Online]. Available: https://waterwindow.nl/casus/dijk-afgekeurd-1.

[11] Paalvast, “Application of string and rope structures, pole and pontoon hulas, to increase productivity and biodiversity in man-made hardsubstrate aquatic environments.,” Caen, 2015.

[12] EcoShape, “Restoring tidal dynamics,” [Online]. Available: https://www.ecoshape.org/en/concepts/restoring-tidal-dynamics/. [Accessed 14 12 2021].

[13] K. T. Post, “Korean Tidal Flats or Getbol – All You Need To Know About,” [Online]. Available: https://www.koreatravelpost.com/korean-tidal-flats-getbol/.

[14] Q. N. Vinh. [Online]. Available: https://www.pexels.com/nl-nl/foto/bruine-blokhuizen-in-het-midden-van-de-zee-3232577/. [Accessed 14 12 2021].

[15] Rijkswaterstaat (Dutch water authority), “Maatregelen rivierengebied (Measures river area),” [Online]. Available: https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/ruimte-voor-de-rivieren/maatregelen-rivierengebied. [Accessed 14 12 2021].

[16] E. a. Society, “Metamorphosis of a Waterway: The City of Nijmegen Embraces the River Waal,” [Online]. Available: https://www.environmentandsociety.org/arcadia/metamorphosis-waterway-city-nijmegen-embraces-river-waal.

[17] USACE, “International Guidelines on Natural and Nature-Based Features for Flood Risk Management,” 2021.

[18] B. e. a. 2020, “unkown”.

[19] DENR, “DENR told subdivisions and hotels: Install rainwater collector,” [Online]. Available: palawandailynews.com.

[20] “Rainsaver,” [Online]. Available: https://www.weida.com.ph/products/rain-harvesting-system/rainsaver-tank/.

[21] Ecoshape, ““You already feel like you’re on a real salt marsh”,” [Online]. Available: https://www.ecoshape.org/en/you-already-feel-like-youre-on-a-real-salt-marsh/.

[22] P. V. Johnson, “Pictures of England,” [Online]. Available: https://www.picturesofengland.com/England/Kent/Whitstable/pictures/1212473.

[23] A. Jensen, Artist, *Photo Manila Bay Mudflat.* [Art].

[24] A. (. v. '. Veld, “Potential measures to reduce fluvial and tidal floods in the Pampanga Delta,” 2015.

[25] Department of Public Works and Highways, “Design Guidelines, Criteria & Standards Volume 3 Water Engineering Projects,” 2015.

[26] D. o. P. W. a. Highways, “Design Guidelines, Criteria & Standards Volume 3 Water Engineering Projects,” 2015.

[27] Rijkswaterstaat (Dutch national water authority), “Maatregelen rivierengebied (Measures for river area),” [Online]. Available: https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/ruimte-voor-de-rivieren/maatregelen-rivierengebied. [Accessed 9 12 2021].

[28] EcoShape, “Creating rich revetments,” [Online]. Available: https://www.ecoshape.org/en/concepts/creating-rich-revetments/. [Accessed 16 12 2021].

Appendix 5

Appendix 5 Location assessment

Population centres along the Coastal Line of Defence

Bulacan, Bulacan

General Overview

The municipality of Bulacan lies along the eastern portion of North Manila Bay. The population centres are situated in the northern part of Bulacan. This part of the municipality is occupied by urban population, farmlands, and fishponds. Meanwhile. The southern part of Bulacan lies in a delta. Fishponds occupy most of the area while population is minimal.

Bambang is a coastal barangay in Bulacan. The population centre is situated in the northern part which lies along the Coastal Line of Defence. Bambang is located north of the New Manila International Airport. Residential houses in Bambang are mainly built along the river while the rest of the barangay consists of farmlands in the north and fishponds in the south which is near the coastline.

Image courtesy: Google Earth Satellite Imagery

Hazard Assessment

Since it is adjacent to the coastline, Bambang is prone to coastal flooding and vulnerable to wave attacks. But since the population centre is located more inland, about 6 km from the coastline, the impact of coastal flooding is moderate while wave attacks are not expected to affect the population. Flood map shows that the area has a moderate susceptibility to fluvial flooding. Damage to property is expected to be moderate as well. The environmental impact of Bambang is low given that mangroves are maintained in the river. Many fisherfolks live in the area and they are concerned that their livelihood may be negatively affected by the flood protection project which could limit their fishing areas.

						
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Hagonoy

General Overview

Hagonoy is a long ridge with a lake on its edge called "Wawa", which is now part of Barangays San Sebastian and San Nicolas. It is basically a fishing town with the Manila Bay as its proximate fishing ground.

Sagrada Familia and San Pablo are inland barangays located along the Coastal Line of Defence. Urban population is situated along the rivers while other areas are mainly fishponds. Fishery is the main livelihood. In Sagrada Familia, former rice fields were converted to fishponds.

Image courtesy: Google Earth Satellite Imagery

Photo: Karen Lovedorial

Hazard Assessment

Sagrada Familia and San Pablo are moderately affected by storm surge based on the hazard map. High tide still contributes to the flooding according to the residents. Wave attacks are not expected to affect the inland areas of Hagonoy. The area has a high susceptibility to fluvial flooding. Water released from the upstream dam, shallow riverbed, and narrowing of river width have contributed to the flooding. The presence of residential houses right beside the river makes the population highly vulnerable to fluvial flooding. Moreover, it was observed in the site visit that some houses are not built strong enough to withstand the impact of flooding. As such, damages to property is expected to be high.

Practices such as building houses within the river and improper solid waste management have negative environmental impacts. The local government has initiated some efforts for flood protection such as mangrove planting and dike construction. This shows the willingness of the institution to participate in the flood protection. A concern of the residents is the maintenance and funding of these measures. During the focus group discussion, residents acknowledged protection of community from flooding as a benefit of nature-based solutions. On the other hand, they are concerned that the project may lead to more limited fishing area, thus affecting their main livelihood. Therefore, social impact tends be more negative.

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Calumpit

General Overview

Calumpit is an inland municipality in Bulacan. It is bounded by Pampanga River in the west while Angat River passes through the center of the municipality. The population centre lies along Bagbag River which connects Pampanga River and Angat River. Fishing and farming are the main livelihood in Calumpit. Associations of farmers and fishermen are established in many barangays.

Photo: Mariane Pajarillo

Photo: Mariane Pajarillo

Hazard Assessment

The population centre is 20 km from the coastline. Based on hazard map, coastal flooding and wave attack are not expected in the area. Calumpit is highly susceptible to fluvial flooding given the proximity of several major rivers. Residents have noted that flood depths range from knee level to more than 1.5 meters. During flood incidents, damages to property are expected in the area. River dikes have helped lessen these damages during less intense flooding. The area has resulted in negative environmental impacts due to dumping of wastes in the river and narrowing of the river width. Local government agencies have shown initiatives in protecting the municipality from flood such as leading cleaning drives to remove water lilies from the river and providing warning signs to the residents for impending floods. Based on the site visit, residents are concerned that flood protection measures may lead to some disadvantages. For example, mangroves can be an obstruction that may negatively affect their livelihood. Saltwater intrusion is another concern of the residents as this will be detrimental to the farm fields.

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Guagua

General Overview

Guagua is an inland municipality in Pampanga. The population centre lies 18 km from the coastline of Manila Bay and more than 3 km north of the Coastal Line of Defense. As such, Guagua is put at a lower priority for the flood protection of North Manila Bay.

The population centre is situated along Guagua River and its tributaries. Guagua River runs southward, eventually reaching Sasmuan and Masantol. The surrounding of the population centre consists of farmlands and fishponds which are main sources of livelihood in the area.

Image courtesy: Google Earth Satellite Imagery

Hazard Assessment

Given its distance from the coastline, Guagua is not prone to the impacts of coastal flooding and wave attacks. The area has moderate to high susceptibility to fluvial flooding. Since the settlement areas are mostly located within the riverbanks, properties are vulnerable and damages are expected during flood events. Land subsidence due to excessive groundwater extraction is a sign of negative environmental impact. Local government has shown initiatives in managing the flood problems in Guagua such as rehabilitation of mangroves. The communities will greatly benefit from the flood protection program and the social situation will generally improve.

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Population centres outside the Coastal Line of Defence

Hagonoy

General Overview

Pugad and Tibaguin are adjacent coastal barangays in Hagonoy with high population density. The population centers lie exactly along Manila Bay and fishing is the main livelihood. Both barangays are surrounded by mooring ports for fishing boats where small boats are docked.

Photo: Karl Wilson Serafica

Hazard Assessment

Pugad and Tibaguin have high susceptibility to coastal flooding due to high tide and storm surge. The areas can also be affected by wave attacks as not all shorelines have dikes to protect the community. Tibaguin also has a high susceptibility to fluvial flooding as it is located at the outfall of Angat River where high flows can be expected specially during typhoons. Previous flood events reached depths between knee level and shoulder level. Damages to property are expected to be moderate to high during intense flood events. It was observed in the site visit that the houses and other structures can be damaged by the floodwaters.

Residents have pointed out that the lack of mangroves and improper waste disposal are negative environmental factors in the area. There is no active association in the area but the local government agencies and BFAR have shown interest in mangrove planting as a flood protection strategy in the area. Social impacts of nature-based solutions are directed both positively and negatively. On one hand, nature-based solutions may revive the natural resources in the area and promote tourism. But on the downside, nature-based solutions may negatively affect their livelihood in the form of reduced fishery resources.

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Masantol

General Overview

Masantol is an inland municipality in Pampanga. Bebe-Esteban Cut-off Channel passes through the northern portion of Masantol while Pampanga River runs towards the south and eventually reaches its outfall in Macabebe. Along the stretch of Bebe-Esteban Cut-off Channel, residential settlements are located right beside the river. Meanwhile along Pampanga River, a buffer zone exists between the river and the settlement areas. This buffer zone is occupied by fishponds. Similar to other places in North Manila Bay, fishing and aquaculture are the main livelihood.

Photo: Karl Wilson Serafica

Hazard Assessment

The population centres in Masantol are more than 6 km away from the coastline. Hazard map shows that these areas have moderate to low susceptibility to coastal flooding. Given the population settlement along two major rivers, it is not surprising that Masantol has high susceptibility to fluvial flood. Previous floods reached depths ranging from knee to chest level. Masantol is not affected by wave attacks since it is located inland.

Many houses are built with materials that can be damaged by destructive floodwaters specially those located right along the riverbanks. In addition, fishponds can be damaged when flooded. As such, high level of damage to property can be expected during flood events. Excessive groundwater extraction has led to land subsidence in the area which could be a factor for flooding. In addition, improper waste management has been pointed out by some residents. Local government units, including the municipal environmental office, have shown interest in protecting the communities from flooding. The Pampanga Coastal Emergency Response is an evidence of the institution's engagement. Residents have some reservations about mangroves since this will limit their livelihood. Additionally, relocation their homes is not an option for them.

						
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Macabebe

General Overview
Macabebe is a coastal municipality in Pampanga. Barangays Consuelo, San Esteban, and Dalayap are located in the southern part of Macabebe which is near the coastline. These barangays also lie between the outfalls of Pasac River and Pampanga River. This area is mainly occupied of fishing ponds, making fishery as the main livelihood. In some places, vegetable planting along the dike has also become a source of living.

Photo: Karl Wilson Serafica

Hazard Assessment
Residents pointed out high tide levels and high flows from upstream during strong typhoons as causes of flooding. This is confirmed by the hazard maps which show that the mentioned barangays are highly susceptible to coastal and fluvial flooding. In preparation for possible flood events, residents have the habit of securing their houses and raising their belongings to higher levels. This helps reduce the property damages.

Improper solid waste management and presence of illegal structures such as fish traps in the river have contributed to negative environmental impacts. The municipal government has shown willingness to engage in flood protection programs. Residents have shown interest in nature-based solutions and they are optimistic about the benefits including livelihood improvement, water quality improvement, marine life development and protection from flood and erosion.

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Lubao

General Overview

Adjacent to the Manila Bay, Bancal Pugad is a barangay lying at the edge of the municipality of Lubao. The population centre is situated in an island surrounded by fishponds and waterways. The population centre is also located along the outfall of Bancal Pugad River. Fishing boats and taxi boats are moored along this river.

Photo: Karl Wilson Serafica

Hazard Assessment

Bancal Pugad is critically located at the encounter of Manila Bay and Bancal Pugad River. This makes the area highly susceptible to coastal and fluvial flooding, particularly during high tide and strong typhoons, respectively. Flood depths can reach 1.5 meters based on the experience of the residents. Damages to properties are expected to be high given the location of the settlements and judging the characteristics of the houses and other structures.

The lack of drainage system, dumping of garbage in the river, and river poisoning are seen as negative points for the environment. Local government units are engaged in the interest of the communities such as for livelihood. Through the implementation of nature-based solutions, residents are expecting to improve the social situation by means of tourism, the opportunity for income, and an increase in fish and oyster population. However, residents are mainly concerned about the manpower needed to maintain the implemented nature-based solutions.

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Paombong

General Overview

Masukol and Santa Cruz are coastal barangays in Paombong, Bulacan while Binakod is an inland barangay north of Masukol. These barangays are located in the delta. Fishing, aquaculture, and farming are the main livelihood in these areas. The population center of Masukol is situated in an island beside Manila Bay.

Photo: Karl Wilson Serafica

Hazard Assessment

These areas are highly prone to coastal and fluvial flooding. Floodwaters normally come from high tide (reaching as high as one meter), dam releases, and excess runoff from typhoons. Shallow riverbed also contributes to the riverine flood. Masukol and Santa Cruz are protected with dikes which help lessen the coastal flood hazard and wave attack. Properties in these areas are vulnerable to the impact of flooding. Improper waste management and land conversion have contributed to negative environmental impacts. Local government units are engaged in various initiatives and efforts for reducing flood risks such as clean-up drives and drainage maintenance. Community initiatives such as coastal clean-ups have also shown the engagement of residents in flood management. Residents expect improvement in the social situation through marine life improvement as a benefit of nature-based solutions. However, residents are mainly concerned about the manpower needed to maintain nature-based solutions as well as the possibility of mismanagement of funds for this project.

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Malolos

General Overview

Priority location in the capital city of Malolos is the southern portion which includes Barangay Pamarawan. This southern portion is situated in the delta and mainly consists of fishponds and farmlands. The population centre of Pamarawan lies at the outfall of Pamarawan River. Livelihood in this area includes fishing, aquaculture, vegetable farming, goat rearing and oyster farming.

Photo: Karl Wilson Serafica

Hazard Assessment

Tidal flooding due to monsoon is a frequent occurrence in Pamarawan. In addition, fluvial floodwaters from upstream areas during strong typhoons contribute to flooding. Frequency of flood ranges from weekly to bimonthly. Flood depths typically reach as high as knee level. The coastal area is also susceptible to wave attacks. Coastal informal settlers are highly vulnerable to flood which leads to strong damages to their home and livelihood.

Improper waste management is also an issue in the area. On the other hand, mangrove and other vegetations are maintained in some areas. Local government agencies have initiated efforts in relation to livelihood of the communities. However, proper coordination with the dam operators are needed to be improved. Residents have expressed concerns about the risk of losing livelihood if flood protection measures are implemented. For instance, dikes prevent the influx of fishes that are a source of livelihood in the area.

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Livelihood and Infrastructure

Pampanga river outfall

General Overview

The land use around the vicinity of the Pampanga river outfall primarily consists of fishponds, a few built-up structures which include a dam/flood gate apart from the structure built along the riverbanks, a few residential houses, and mangrove forest. The locals residing in the area expect that the formulated nature-based solution in the area will protect them against flooding.

Image courtesy: Google Earth Satellite Imagery

Photo: Karl Wilson Serafica

Photo: Karl Wilson Serafica

Hazard Assessment

Being located at the downstream part of the Pampanga River, the area is prone to coastal flooding and river flooding in addition to flooding due to the release of water from dams, tidal flooding, and coastal storm surges. The area is also susceptible to liquefaction, tsunami, and land subsidence based on the available hazard maps. During the ocular inspection, it was observed that the road shoulders are eroded primarily because of exposure to tides and waves.

Residents living in this area confirm that flooding reaches up to waist level and that in the event of a coastal hazard, they are always at risk of losing their livelihood (mostly fishermen). Severe damages to houses and furniture were also reported by the locals. With this, warning systems such as sirens, news outlets, and text messages, are made available by their LGUs. They also mentioned that if they must evacuate, safe transportation and shelter are accessible.

The location of the built infrastructures at the mouth of the Pampanga river possibly contributes to the flooding in the upstream areas by impeding the natural flow of the river towards Manila bay. Demolition of a portion of the said infrastructures may have to be done along with the proposed nature-based solutions and may need coordination from the respective LGUs. Affected properties such as residential houses and camping sites must also be considered in choosing the appropriate actions. Few residential areas may have to be relocated along with the camping site at the western road. Finally, concerns as to whether these solutions will be maintained properly, and if will take up too much space which in turn would limit their livelihood and mobility were reported during the community visit.

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Angat river

General overview

Angat river outfall is located along the coastline boundaries of Barangay Tibaguin and Barangay Pugad in Hagonoy, Bulacan. The discharge points where the tributaries of the Angat river forks, and where the river meets Bulacan municipality water (Barangay Pugad) is densely packed with residential areas on the western area. On the other hand, fishponds primarily comprise its eastern part. With this project ,the locals expect that the current situation in the area will go back to the previous times (until the 2000s) where coastal hazards cause little to no damage to properties, and that this will improve livelihoods. The locals also asserted that implementing offices must consider the how and who will maintain these Nature-based solutions. The residents are familiar with Nature-based solutions and prefer the use of combined mangrove & fishpond to mitigate or at least reduce damages brought by the coastal hazards. Aside from the protection of properties, the locals regarded nature-based solutions to support rich biodiversity which will positively impact livelihood and will promote tourism in the area.

Image courtesy: Google Earth Satellite imagery

Photo: Karl Wilson Serafica

Photo: Karl Wilson Serafica

Hazard Assessment

The community situated in this zone is highly susceptible to a combination of coastal & Angat river flooding. The residents confirm that the depth of floodwater reaches neck level and wave attacks are also experienced in the area. Frequent damage to properties and additional expenses for repair and recovery of these damages are inevitable during these extremities which lead some of the residents to just abandon the place. As per the community household interview, the main source of income in the area is either fishing or street vending which is why in any event that will extremely heighten the water level, the residents are always at risk of losing livelihood. Meanwhile, during the stakeholder visit in the area, local fishermen pointed out that the causes of flooding could be poor solid waste management, lack and deterioration of mangroves, and reclamation projects.

During the site visits, it was also observed that there was a lot of solid wastes in the area which was, as the residents claim, came from far upstream areas. Since flooding is common in the area, warning systems, access to transportation, and safe routes to shelters are made available by the local government. The aforementioned stakeholder entity is also actively

seeking to adopt suitable Nature-based solutions in the area taking into consideration that the people would prefer not to relocate because of their livelihood. Furthermore, residents who participated in the FGD are not aware of any community or association initiatives that will be helpful once nature-based solutions are implemented. Lastly, concerns on the possible negative impact of the project on their livelihood were also brought up by the locals.

						
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Pamarawan River Outfall

General Overview

Pamarawan river outfall is situated along the outskirts of Malolos, Bulacan. Typical site coastal features can be identified in the area such as fishponds, residential structures which are concentrated along the borders, and flood mitigation measures such as reinforced concrete walls and pilapil embankments. Fishing, farming, goat rearing, oyster farming, aquaculture, street vending, and boat driving are some of the livelihoods recorded during the household survey.

Image courtesy: Google Earth Satellite imagery

Hazard Assessment

The residents living adjacent to Pamarawan river outfall reported experiences regarding flooding from the river and Manila bay. High tide and the release of water from the dam were also perceived as sources of flooding. Flood level in the area reaches up to chest level which disrupts the livelihood and damages the properties of the locals. The presence of solid wastes at the mouth of the Pamarawan river was observed during the site visit which was perceived as one of the causes of flooding along with inadequate drainage system, ineffective implementation of flood mitigation projects, and lack of coordination with the LGU and dam operators. Warnings from MDRRMC via text messages, social media, and TV news give the residents time to raise their belongings to higher places, moor their boats, and refill 'pilapil' embankments.

In addition to the warning systems, Malolos LGU also initiated the modernization of fishing, in addition to livelihood training, and coordinated with BFAR regarding funding for the fisherfolks. The communities within the municipality of Malolos have various associations which can support the LGU and the projects on the implementation of nature-based solutions. Some of the associations in Pamarawan mentioned during the FGD are Samahan ng Mangingisda, Samahan ng Namamanti, and Samahan ng Kalipunan ng Mangingisda sa Malolos. Furthermore, the fishermen also shared their concerns regarding the risk of blocking the influx of fish and other marine life which will consequently lead to the Pamarawan residents losing their source of income.

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Macabebe fishponds

General Overview

Macabebe, Pampanga is bounded by connected rivers on the west, fishponds on the north & east, and Manila bay on the south. River channels also cut across Macabebe where most of the residential structures are erected along its banks. Fishponds cover most of this municipality. Fishing and farming are the usual form of livelihood in Macabebe.

Image courtesy: Google Earth Satellite imagery

Photo: Karl Wilson Serafica

Hazard Assessment

The locals imparted that the flood levels range from waist level to neck level. In parallel, the group of fisherfolks who participated in the focus group discussion asserted that the causes of flooding aside from the forking of waters from Dagupan river & Apalit river, and Manila Bay & Pampanga river, are the illegal structures like fish traps amidst the river, inadequate drainage system, blockage of drainage way because of water lilies, and ineffective solid waste management. Being bounded by multiple water systems, the fishpond in the area is vulnerable to fluvial flooding while those lying in the southern boundary are prone to coastal flooding and wave impacts. Severe damages to livelihood and properties around the Macabebe fishpond vicinity due to this coastal hazard were reported.

It was mentioned during the FGD that pavement elevation by the LGU causes flooding to the nearby properties. Future projects that will be implemented should be properly coordinated to prevent this scenario. By the end of the discussion, the participants expect the nature-based solutions to ¬promote a better marine environment for their livelihood which can be observed by both the quantity and quality of the fish they could harvest, and protect the citizens against erosion, flooding, and waves. Protection of the fishponds and their properties is also a must since fishing is their main source of livelihood that is why they also prefer a solution that could provide their fishponds a better water inflow.

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Hagonoy fishponds

General Overview

Hagonoy, Bulacan is bounded to the west by the municipality of Masantol, to the north by the municipality of Calumpit, to the east by Angat river and the municipality of Paombong, and to the south by its municipal waters. Barangays namely - Mercado, Sagrada Familia, San Jose, San Pablo, San Pascual, Santa Elena, Santa Monica, and Tampok are among the places in Hagonoy which lies outside the coastal line of defence together with barangays San Roque, Pugad, and Tibaguin lying on its coastal borders.

The area of Hagonoy in between the coastline and its line of defense is traversed by multiple networks of inland water and has a prevailing land cover of fishponds. Few built-up structures and mangroves are shown in land cover maps from NEDA. Moreover, discourses with the residents reveal that drying fish, fishing, farming, aquaculture, and street vending are amongst the most common form of livelihood in the area.

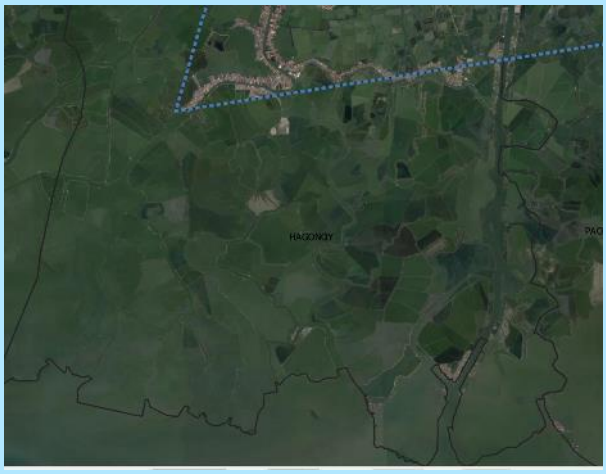

Image courtesy: Google Earth Satellite imagery

Hazard Assessment

The fishponds near the coastline are most susceptible to coastal flooding and wave attacks based on hazards maps and as confirmed by the residents. Since multiple networks of water systems cut across Hagonoy, fishponds lying adjacent to those inland waters are vulnerable to fluvial flooding. Aside from this, the locals reported that flooding is possibly caused by from improper implementation of dikes, high tide, narrowing of river, dam release, shallow riverbed, in adequate solid waste management, reclamation projects, and destruction of mangroves. Damages to properties including residential structures and livelihood are commonly experience in the area when coastal hazards occur.

Moreover, the residents disclosed that some of the farmlands (rice fields) were converted to fishponds. There are few communities in Hagonoy such as “Samahan ng mangingisda ng Hagonoy”. Like the fisherfolks, the LGU representatives of Hagonoy are very keen on implementing nature-based solutions in the area and have initiated several projects to aid the residents regarding flooding problems. However, the locals expressed worries regarding conditions of aquaculture ponds, fishing zones, and existing ‘pilapil’ once the nature-based solutions were implemented as these might decline earnings

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Lubao fishponds

General Overview

Moving clockwise from the south-western borders of Lubao in Pampanga, the municipality is surrounded by Orani and Hermosa in Bataan, Floridablanca, Guagua, and Sasmuan in Pampanga, and lastly the municipal waters of Sasmuan and Lubao.

Small parts of Barangays Calangain, Remedios, San Juan (Pob.), Santa Barbara, Santa Catalina, Santa Cruz, and Santa Lucia (Pob.) are located outside of the coastline of defence. On the other hand, Barangays Baruya (San Rafael), Bancal Sinubli, Bancal Pugad, San Jose Gumi, and Santa Teresa 2nd are declared as the coastal barangays in the municipality based on NEDA administrative maps.

Based on the land cover maps of NEDA, the area of Lubao in between the coastline and its line of defence are mostly fishponds, few farmlands and grass lands, mangroves, inland water, and residential structures which are concentrated either near coastal line of defence or near riverbanks. Livelihood in the area is mostly fishing, aquaculture related such as fishpond labourer and fishpond security personnel, taxi boat driving, and street vending. Source of potable water in the is deep well.

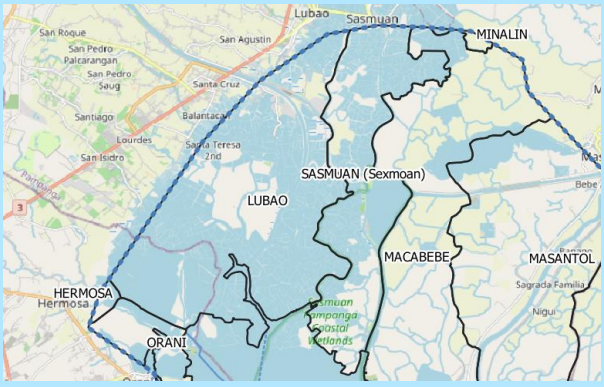

Image courtesy: OpenStreetMap with NEDA Maps

Photo: Karl Wilson Serafica

Hazard Assessment

Fishponds located near coasts are exposed to a combination of coastal flooding and river flooding. While those bounded by river tributaries are most in a highly susceptible site for fluvial flooding. Information from the residents declares that the flood depth reaches above 1.5m and frequent flood occurrences in the area severely impact their livelihood since most of if are nature-based and therefore are easily affected. Sources of floodwater are from the forking of tides and rivers, and typhoons. Improper solid waste disposal, residents' utilization of deep wells as a source of water possibly contributing to land subsidence, inadequate drainage management, as well as upstream waters are also perceived to contribute to flooding.

Prior to onslaughts of coastal hazards, dissemination of information via barangay warning system, LGU reminders, news, and text messages are utilized so the residents could prepare themselves. These preparations include, but not limited to, evacuating, raising of belongings, mooring of boats, and securing of roods. Safe access transportation to shelter are also available should the need to evacuate arises.

The participants of the FGD in Lubao are not aware of any associations in the site. However, the representatives are aware of the LGU efforts to support livelihood which are done through provision of fishnet and boat items or accessories. During the site visit and community discussion, the residents appear familiar with the utilization of nature-based solutions and expect it to improve livelihood, increase the opportunity of income since nature-based solutions promote growth in biodiversity and increase chances of attracting tourism.

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Sasmuan fishponds

General Overview:
Sasmuan is one of the outlying coastal municipalities of Pampanga along with Lubao and Macabebe. Going clockwise from the west, Sasmuan is bounded by Lubao, Guagua, Minalin, Macabebe, and Sasmuan municipality waters. Bancal Pugad river, Sebitanan river, Mayapap river, Porac-Gumain River, Batasan River, Estaka River, Guagua river, and Pasac river are among the several rivers that outlines the borders of Sasmuan and separates the municipality to another.

Barangays San Antonio, San Pedro, Santa Monica, Batang 1st, Batang 2nd, Mabuanbuan, Malusan, and Sabitanan are the barangays that are located outside the coastline of defense with the last five being the coastal barangays based on the administrative map from NEDA.

Most of the site is covered by aquaculture ponds with few areas made up of mangroves, inland waters, and residential structures.

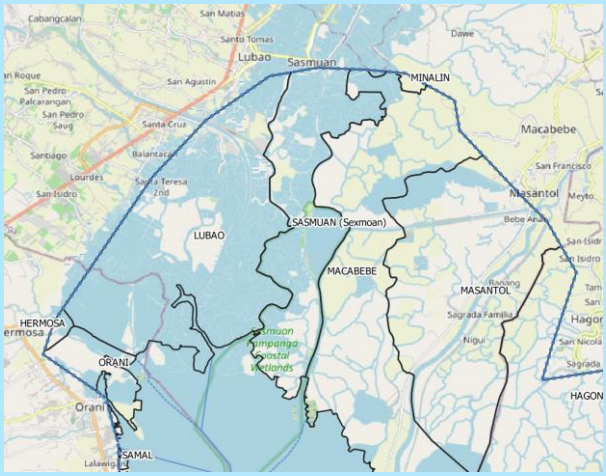

Image source: OpenStreetMap with NEDA Maps

Hazard Assessment
Based on the hazard maps, the barangays of Sasmuan located outside coastal line of defence is prone to flooding and liquefaction. Meanwhile, declared coastal barangays are most susceptible to coastal storm surges and tsunami. Coastal hazards in this area poses risk to fishponds especially those lying on the outskirts of the coastline and banks of rivers. Furthermore, Batang 1st, Batang 2nd, Mabuanbuan, Malusan, and Sabitanan makes up the boundary which was declared as a “Wetland of International Importance” by DENR as is also called as Sasmuan Pampanga Coastal Wetlands (SPCW) Ramsar Site. According to del Rosario of the Philippine News Agency (2021), this ecosystem hotspot plays a significant role both in ecological biodiversity and rehabilitation of Manila Bay.

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Paombong fishponds

General Overview

The municipality of Paombong is bounded on the west by the municipality of Masantol in Pampanga, on the north by the municipality of Calumpit in Bulacan, on the east by the municipality of Malolos, and on the south by the municipal waters of Hagonoy, Paombong, and Bulacan. Aquaculture, fishing, 'tuba' gathering (nipa vinegar), and farming are declared to be the most known sources of income in the municipality.

Image courtesy: OpenStreetMap with NEDA Maps

Photo: Karl Wilson Serafica

Hazard Assessment

During the household survey, locals reported experiences of the flood that reached up to chest level, and possible coastal hazard sources may be flooding from the river, flooding from the sea, wave impact, high tide, winds, and release of water from the dam. From both the surveys and geohazard maps, it could be inferred that fishponds along the Paombong coastline and riverbanks are most susceptible to coastal flooding and fluvial flooding, respectively. Damages to properties during coastal hazard occurrence ranges from minor damages to furniture to damage to entire house structures. Livelihoods are reported to suffer the most impact in the area during these events.

Moreover, conversions of farmland to fishponds and fishponds to residential are perceived to be some of the causes of flooding as reported during the FGD. Fishermen and LGU initiated collaboration for clean-up drives and drainage maintenance. LGU initiative also includes the conversion of the sanitary landfill to an eco-park that is open to the public. The residents shared that the implemented Nature-based solution would revive the dying mangroves in the area. Maintenance and protection of mangroves must also be enforced as to not repeat the previous shortcomings of mangrove planting projects in the area.

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Malolos fishponds

General Overview

Most areas in Malolos, Bulacan is located inside the coastline of defence. The rest are bounded on the west, east, and south by Paombong municipality, Bulacan municipality, and its municipality waters. Amongst the rivers that runs across this area are Lagyo, Pangagtan, Galas, Malolos, Lico-lico, Malaway, Bugwan and Pamarawan river. The latter significantly traversed the area of Malolos outside the coastline of defence. Aside from aquaculture and fishing, farming, goat rearing, oyster farming, street vending, and boat driving are the common livelihoods of the residents interviewed.

Image courtesy: OpenStreetMap with NEDA Maps

Photo: Karen Lovedorial

Hazard Assessment

Due to the location characteristics of Malolos, fishponds in the area are prone to both coastal flooding and fluvial flooding. As per hazard maps, this site is also highly susceptible to liquefaction, storm surges, and tsunami. Residents also reported flood levels reaching up to chest level. Since most of the locals depend on aquaculture ponds and fishing zones for living, their livelihood suffers critically together with the destruction of their properties.

Most of the LGU initiatives, which the residents are aware of, focuses mainly on livelihood. The communities within the municipality of Malolos has various associations which can support the LGU and the projects on the implementation of nature-based solutions. Some of the associations mentioned during the FGD are Samahan Bigkis Tungo sa Kaunlaran in Caliligawan, Samahan ng Kalipunan ng Mangingisda sa Malolos, Samahan ng mga Mangingisda (in Masile, Pamarawan, Calero), Samahan ng Namamanti in Pamarawan, Samahan ng mga may Palaisdaan in Masile, and FARM-C. Furthermore, the fishermen also shared their concerns regarding the risk of blocking the influx of fish and other marine life which will consequently lead to the residents of Malolos losing their source of income.

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Appendix 6

Appendix 6 Maps

Appendix 7.1 BI2434-RHD-DA-XX-DR-0001 Area Overview
Appendix 7.2 BI2434-RHD-DA-XX-DR-0002 Existing Site Features Overview
Appendix 7.3 BI2434-RHD-DA-XX-DR-0003 Population Center and Priority Locations
Appendix 7.4 BI2434-RHD-DA-XX-DR-0004 Bulacan and Pampanga Nature-based Solutions

AREA OVERVIEW OF NORTH MANILA BAY

GUAGUA
LUBAO
SASMUAN (Sexmoan)
CALUMPIT
MACABEBE
PAMPANGA
MASANTOL
CITY OF MALOLOS (Capital)
HAGONOY
PAOMBONG
BULACAN
San Jose Gumi
Santa Teresa 2nd
Bancal Sinubli
Malusac
Baruya (San Rafael)
Sabitanan
Bancal Pugad
Batang 1st
Mabuanbuan
Batang 2nd
Kabalutan
Palihan (Pob.)
Pantalan Bago (Pob.)
Pantalan Luma (Pob.)
Kaparangan
Lalawigan
Tabing Ilog
Ibaba (Pob.)
Santa Lucia
Sapa
East Calaguiman (Pob.)
Mabatang
Calaylayan (Pob.)
Consuelo
Sapang Kawayan
San Roque
Pugad
Tibaguin
Masukol
Santa Cruz
Caliligawan
Pamarawan
San Nicolas
Bambang
Taliptip
Obando
Binuangan
Obando
Salambao
Tanza
Tangos
Lubao
Sasmuan
Orani
Samal
Macabebe
Abucay
Hagonoy
Bay Area
City of Malolos
Paombong
Bulacan
Obando
Navotas City
240000
250000
260000
270000

PROPONENT/DEVELOPER

Netherlands Enterprise Agency

NOTES

This study is named the North Manila Bay Flood Protection Strategy, a follow-up from the MBSDMP, and is funded by the Netherlands Enterprise Agency. The goal of this study is:

"To develop a Flood Protection Strategy which identifies sustainable, nature-based flood protection measures for the Northern Manila Bay coastal area."

The goal is to take action with the priority measures of the MBSDMP. Royal HaskoningDHV assisted by a pool of experts including Wetlands International Philippines used their expertise to prepare this feasibility study that may operationalize implementation to "Reduce Exploring in Flooding" action plan

NORTH MANILA BAY FLOOD PROTECTION STRATEGY

LEGENDS

BOUNDARY

- Coastal Line of Defense (MBSDMP)
- Administrative Provincial Boundary (MBSDMP)
- Administrative Municipality Boundary (MBSDMP)
- Coastal Barangay Boundary (MBSDMP)
- Municipal Waters Boundary (MBSDMP)

PROJECT SITE

PROJECT : NORTH MANILA BAY FLOOD PROTECTION STRATEGY

RHDHV PROJECT NO. : SF1211

VERSION: P01

SCALE : 1:60000

DOCUMENT REFERENCE : SF1211-RHD-CN-XX-DR-0001

DESIGNER:

Royal HaskoningDHV
Enhancing Society Together

EXISTING SITE FEATURES OVERVIEW OF NORTH MANILA BAY

GUAGUA
CALUMPIT
Community Airport
LUBAO
SASMUAN (Sexmoan)
MACABEBE
PAMPANGA
MASANTOL
CITY OF MALOLOS (Capital)
BATAAN
HAGONOY
PAOMBONG
BULACAN
Lubao
Sasmuan
Orani
Samal
Bay Area
Macabebe
Abucay
Hagonoy
City of Malolos
Paombong
Obando
Obando
Bulacan
NCR, THIRD DISTRICT (NOT A PROVINCE)
Obando
Navotas City

PROPONENT/DEVELOPER

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NORTH MANILA BAY FLOOD PROTECTION STRATEGY

LEGENDS

BOUNDARY
- Coastal Line of Defense (MBSDMP)
- Administrative Provincial Boundary (MBSDMP)
- Administrative Municipality Boundary (MBSDMP)
- Municipal Waters Boundary (MBSDMP)

EXISTING SITE FEATURES
- River Basin
- Waterways (NAMRIA)
- Builit-up
- Annual Crop
- Brush/Shrubs
- Fishpond
- Grassland
- Mangrove Forest
- Marshland/Swamp
- Open/Barren
- Perennial Crop
- Digitized Mangroves
- MBD Offshire Mining Application

PROJECT SITE

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SF1211

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DESIGNER:

Royal HaskoningDHV
Enhancing Society Together

POPULATION CENTERS AND PRIORITY LOCATIONS

Guagua
MINALIN
Calumpit
SASMUAN (Sexmoan)
LUBAO
Sasmuan fishponds
Macabebe fishponds
Lubao (Bancal Sinubli)
Macabebe (San Esteban)
PAMPANGA
MACABEBE
MASANTOL
Masantol
HERMOSA
Lubao (Bancal Pugad)
ORANI
Hagonoy
Lubao
Pasac river oufall
Macabebe (Consuelo)
Hagonoy fishponds
Sasmuan
HAGONOY
Orani
Paombong fishponds
PAOMBONG
Bulacan, Bulacan
Malolos fishponds
Pampanga river outfall
Hagonoy (Pugad and Tibaguin)
BULACAN
Angat river outfall
Samal
SAMAL
Paombong (Santa Cruz)
Malolos
BULACAN
CITY OF MEYCAUAYAN
ABUCAY
Macabebe
Abucay
Obando
OBANDO
Obando
Hagonoy
City of Malolos
Paombong
Bulacan
NCR, THIRD DISTRICT (NOT A PROVINCE)
Obando
Navotas City

240000 250000 260000 270000

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NORTH MANILA BAY FLOOD PROTECTION STRATEGY

LEGENDS

BOUNDARY
- Coastal Line of Defense (MBSDMP)
- Administrative Provincial Boundary (MBSDMP)
- Administrative Municipal Boundary (MBSDMP)
- Municipal Waters Boundary (MBSDMP)

PRIORITIZED LOCATIONS
- Population centres inside coastal lines of defense
- Population centres outside coastal line of defense
- Livelihood and Infrastructure

PROJECT SITE

PROJECT : NORTH MANILA BAY FLOOD PROTECTION STRATEGY
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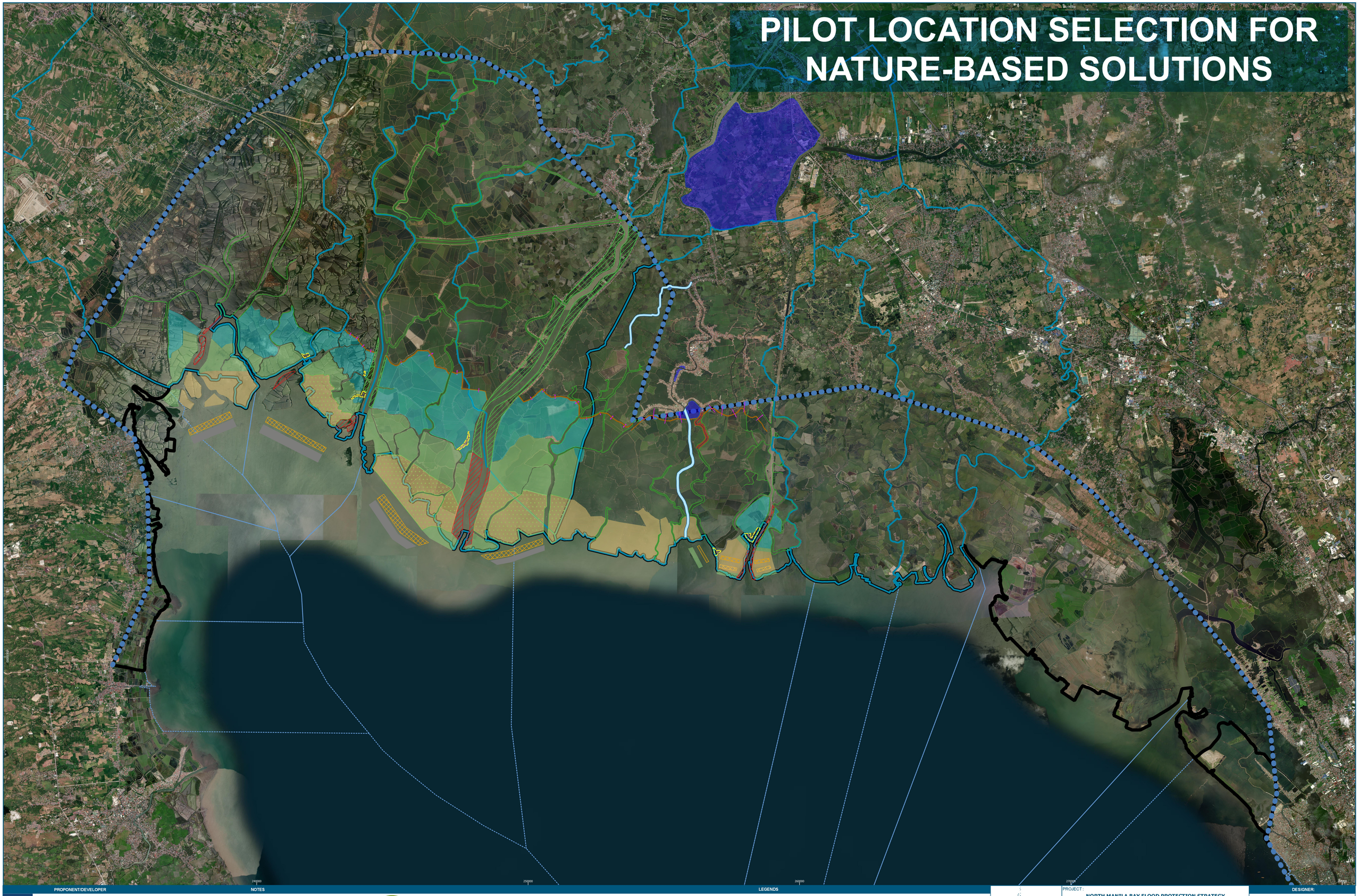
PILOT LOCATION SELECTION FOR NATURE-BASED SOLUTIONS



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NORTH MANILA BAY FLOOD PROTECTION STRATEGY

LEGENDS

BOUNDARY

- Coastal Line of Defense (MBSDMP)
- Administrative Provincial Boundary (MBSDMP)
- Administrative Municipal Boundary (MBSDMP)
- Municipal Waters Boundary (MBSDMP)

NATURE-BASED SOLUTIONS

- Riverbank restoration mangroves
- Room for river
- Mangrove green belt
- Hanging and floating structures
- Tidal flat restoration
- Enhanced breakwater
- Green embankment
- Inland earth dike
- Sustainable fishponds
- Increase sediment discharge
- Shellfish reefs
- Adaptive housing
- Retention basin
- Surge gates
- Culvert
- River diversion

PROJECT SITE

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DESIGNER:

Royal HaskoningDHV
Enhancing Society Together

Appendix 7

Appendix 7 Conceptual Cost Estimates

Masantol and Macabebe Green Embankments

Project Management		
Quantities	**Value**	**unit**
ABB-BP or LGU representative full time	8	Months
Stakeholder management	8	Months
Expert support (Nature based solutions)	2	Months
Expert support (Coastal engineering)	2	Months
Contracting	3	Months
Supervision	6	Months
Design	6	Months
Surveys	1	Lump sum
Unit rates		
ABB-BP or LGU representative full time	20	[$/hour]
Stakeholder management	20	[$/hour]
Expert support (Nature based solutions)	100	[$/hour]
Expert support (Coastal engineering)	100	[$/hour]
Contracting	50	[$/hour]
Supervision	20	[$/hour]
Design	20	[$/hour]
Surveys	8,000	[$]
Cost estimates		
ABB-BP or LGU representative full time	3,632	[$]
Stakeholder management	3,632	[$]
Expert support (Nature based solutions)	4,540	[$]
Expert support (Coastal engineering)	4,540	[$]
Contracting	3,405	[$]
Supervision	2,724	[$]
Design	2,724	[$]
Surveys	8,000	[$]
Total costs project management	**33,197**	**[$]**

Revetment removal		
Parameters	**Value**	**unit**
Crest witdh	10	[m]
Slope	2	[1:x]
Crest level	3	[m MSL]
Toe level	-1	[m MSL]
Armour thickness	0.3	[m]
Asphalt thickness	0.3	[m]
Length green embankment	2000	[m]
Quantities	**Value**	**unit**
Core material	130,800	[m3]
Revetment	9,600	[m3]
Asphalt	3,600	[m3]
Unit rates	**Value**	**unit**
Removal and re-use revetment	8	[$/m3]
Cost estimates	**Value**	**unit**
Removal and re-use revetment	76,800	[$]

Green embankment construction		
Parameters	**Value**	**unit**
Berm witdh	10	[m]
Upper Slope	3	[1:x]
Lower slope	3	[1:x]
Berm level	0	[m MSL]
Bed level	-1	[m MSL]
Clay thickness	0.5	[m]
Length green embankment	2000	[m]
Length slope	22	[m]
Dredging width	30	[m]
Quantities	**Value**	**unit**
Supply core material	69,000	[m3]
Supply clay	22,000	[m3]
Supply coconets	44,000	[m2]
Supportive planting	44,000	[m2]
Unit rates	**Value**	**unit**
Supply core material (re used dredge)	3	[$/m3]
Supply clay	6	[$/m3]
Supply coconets	4	[$/m2]
Supportive planting	2	[$/m2]
Cost estimates	**Value**	**unit**
Supply core material	207,000	[$/m3]
Supply clay	132,000	[$/m3]
Supply coconets	176,000	[$/m2]
Supportive planting	88,000	[$/m2]
Total costs Breakwater	**603,000**	**[$]**

Pampanga River outfall

Project Management		
Quantities	**Value**	**unit**
ABB-BP or LGU representative full time	24	Months
Stakeholder management	24	Months
Expert support (Nature based solutions)	12	Months
Expert support (Coastal engineering)	12	Months
Contracting	6	Months
Supervision	48	Months
Design	48	Months
Surveys	1	Lump sum
Unit rates		
ABB-BP or LGU representative full time	20	[$/hour]
Stakeholder management	20	[$/hour]
Expert support (Nature based solutions)	100	[$/hour]
Expert support (Coastal engineering)	100	[$/hour]
Contracting	50	[$/hour]
Supervision	20	[$/hour]
Design	20	[$/hour]
Surveys	50,000	[$]
Cost estimates		
ABB-BP or LGU representative full time	10,896	[$]
Stakeholder management	10,896	[$]
Expert support (Nature based solutions)	27,240	[$]
Expert support (Coastal engineering)	27,240	[$]
Contracting	6,810	[$]
Supervision	21,792	[$]
Design	21,792	[$]
Surveys	50,000	[$]
Total costs project management	**176,666**	**[$]**

Dike removal		
Parameters	**Value**	**unit**
Crest witdh	10	[m]
Slope	2	[1:x]
Crest level	3	[m MSL]
Toe level	-1	[m MSL]
Armour thickness	0.3	[m]
Asphalt thickness	0.3	[m]
Length dike	3500	[m]
Quantities	**Value**	**unit**
Core material	228,900	[m3]
Revetment	16,800	[m3]
Asphalt	6,300	[m3]
Unit rates	**Value**	**unit**
Removal core material and re-use	2	[$/m3]
Removal and re-use revetment	4	[$/m3]
Removal asphalt	8	[$/m3]
Cost estimates	**Value**	**unit**
Removal core material and re-use	457,800	[$]
Removal and re-use revetment	67,200	[$]
Removal asphalt	50,400	[$]
Total costs removal dike	**575,400**	**[$]**

Breakwater construction with re-used material		
Parameters	**Value**	**unit**
Crest witdh	2	[m]
Slope	3	[1:x]
Crest level	3	[m MSL]
Toe level	-2	[m MSL]
Armour thickness	2	[m]
Length breakwater	1500	[m]
Dredging depth	8	[m]
Dredging width	30	[m]
Quantities	**Value**	**unit**
Dredgeding and seabed raising	360,000	[m3]
Core material	127,500	[m3]
Revetment	45,000	[m3]
Additional material behind breakwater	461,400	[m3]
Unit rates	**Value**	**unit**
Dredging and seabed raising	2	[$/m3]
Core material	Re-use	
Revetment	40	[$/m3]
Cost estimates	**Value**	**unit**
Dredging and seabed raising	720,000	[$]
Core material	Re-use	
Revetment	1,800,000	[$]
Additional material behind breakwater	Covered by other rates	
Total costs Breakwater	**2,520,000**	**[$]**

Aquaculture solutions		
Quantities	**Value**	**unit**
Shell fish reefs (3 rows)	4500	[m]
Hanging structures	5	[hec]
Unit rates	**Value**	**unit**
Shell fish reefs	120	[$/m]
Hanging structures	20	[$/m2]
Cost estimates	**Value**	**unit**
Shell fish reefs	540,000	[$/m]
Hanging structures	1,000,000	[$/m]
Total costs aquaculture innovations	**540,020**	**[$]**