THE INSTITUTION OF ENGINEERS MALAYSIA

POSITION PAPER ON THE IMPACTS OF SEA LEVEL RISE ON COASTAL COMMUNITIES AND DEVELOPMENT

1.0 SYNOPSIS

This paper reflects the understanding of the Institution of Engineers Malaysia on potentail impacts of sea level rise on Malaysia's coast and its implication towards engineering and engineers. Sea level rise affects socio-economic activities within the coastal zone. It poses an inundation and erosion threat towards coastal communities, property and infrastructure. The sea level rise projection based on IPCC AR5 in 2017 indicated that local sea levels will rise by 0.68 to 0.73 m by 2100. The northeast region of Peninsular Malaysia and the north region of Sabah is predicted to be the most affected.

2.0 EXECUTIVE SUMMARY

2.1 The Institution of Engineers Malaysia is cognizant of the demands of sustainable development and engineering solutions must not negatively impact the natural environment. Towards achieving this balance, the members of IEM collectively accept the technical challenge it has posed. This position paper aims to recommend pragmatic measures to improve the quality, safety and integrity of coastal and maritime structures for long-term effectiveness against hazards enhanced by sea level rise. Both structural and non-structural efforts must be in place to mitigate impacts of SLR.

2.2 About 1,348 km or 15% of Malaysia's coastline was found to be eroding in 2015 (DID, 2015). Sea level rise will further aggravate the condition if the erosion is unmitigated. PLANMalaysia (2019) is currently preparing Rancangan Fizikal Zon Persisiran Pantai Negara 2 (RFZPPN2), which complements Rancangan Fizikal Negara (RFN). The document that is to be published in 2021 provides guidance on land use and development within the coastal zone by assessing the coastline's vulnerability. Sea level rise is a major factor in the assessment.

Broad principles for addressing sea level rise in the coastal zone are (CCC, 2018):

(a) Use science to guide decisions;
(b) Minimise coastal hazards through planning and development standards;
(c) Maximise protection of public access, recreation and sensitive coastal resources; and

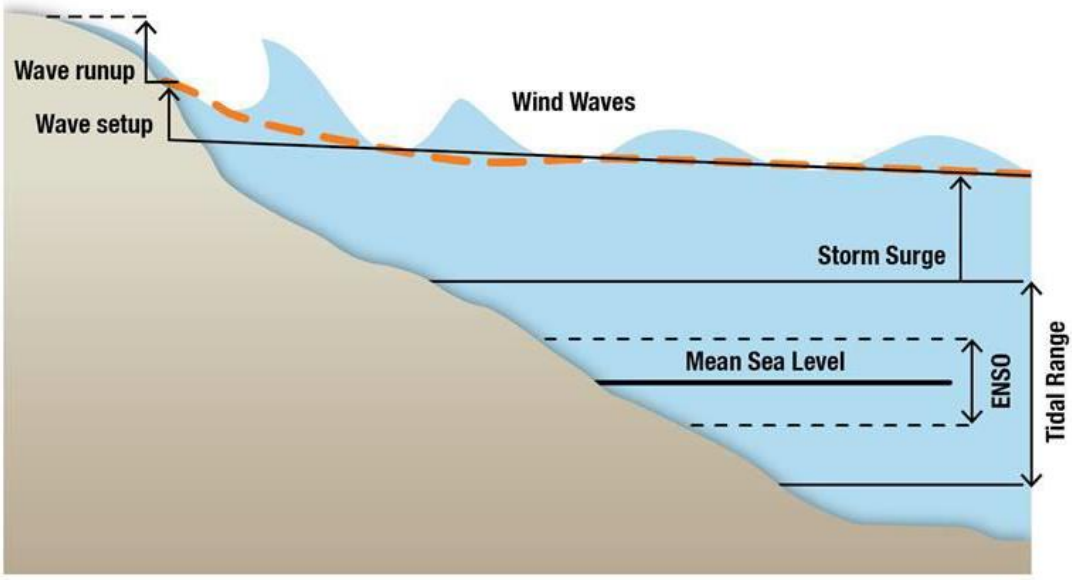
(d) Maximise departmental and agency coordination as well as public participation.

Keywords: Sea level rise, impact, intervention, adaptation

3.0 THE ISSUES

3.1 Global warming is causing global mean sea level to rise. Sea level rise is globally caused by two primary reasons i.e. expansion of saltwater as it warms and loss of ice on land (IPCC, 2019). Sea level rise has been identified as one of the significant climate change effects that will impact Malaysia. Other factors such as storms, erosion and accretion act together with changes in sea level to shape the size and makeup of Malaysia's coastlines, wetlands and rivers. Sea level rise may progressively become the driving force in coastal changes as it accelerates. 8,600 km of the nation's coastline, where 70% of its 30 million population resides, will immediately lose a portion of its inter-tidal land to the sea upon sea level rise. Accelerated rates of sea level rise could cause inundation of low-lying land, saltwater intrusion into groundwater and streams and increased extent and severity of coastal flooding (Delaware Coastal Programs, 2012).

3.2 Sea level rise results in the deepening of the sea thereby increasing tidal inundation, propagation of storm surge as well as magnitude of waves and currents; these factors are the driving forces of erosion and sedimentation (Figure 1).



Source: McInnes et al., 2017

Figure1: Various contributors to sea-level extremes

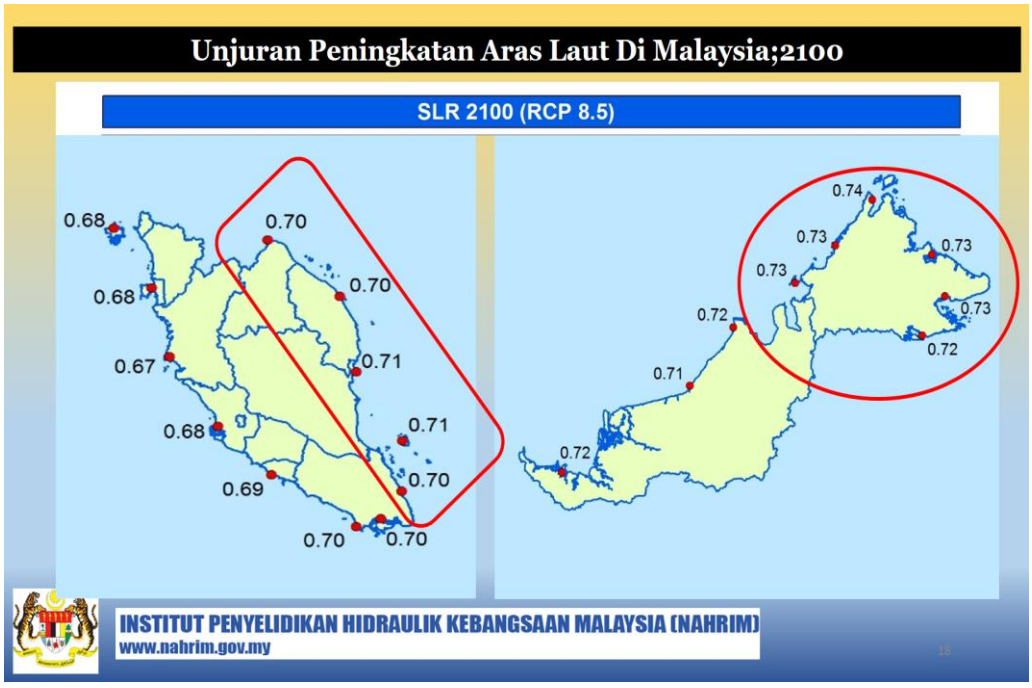
Of significance, is the concern on the capability of Malaysia's coastal communities to adapt under the threat of rising sea levels, directly or indirectly. An important aspect of this sustainability is the integrity and

efficiency of existing coastal and maritime infrastructures to perform their respective functions.

3.3 Sea level rise is a phenomenon that manifests over time. Future engineering intervention should be timely, properly planned and communicated. The cost of protecting coastal lands and property against inundation and erosion is very expensive. Therefore, prevention or pre-empting through adequate planning is necessary. Coastal development is exposed to erosion risk if development setbacks and buffer zones are not established or compromised. Design factors of safety incorporating sea level rise are currently not mandated for design of coastal structures.

4.0 SEA LEVEL RISE IN MALAYSIA

4.1 In 2017, NAHRIM projected that the sea level in 2100 ranged between 0.68 m to 0.73 m (RCP 8.5) throughout the Malaysian coastline by 2100 based on IPCC Assessment Report No. 5 (released in 2014) (Figure 2). These projections were assessed to represent the likely range (66% probability), which was evaluated from 5 to 95% range of the model results. They do not include any additional allowance of several tenths of a meter that might occur if there was significant collapse of the Antarctic ice sheet.



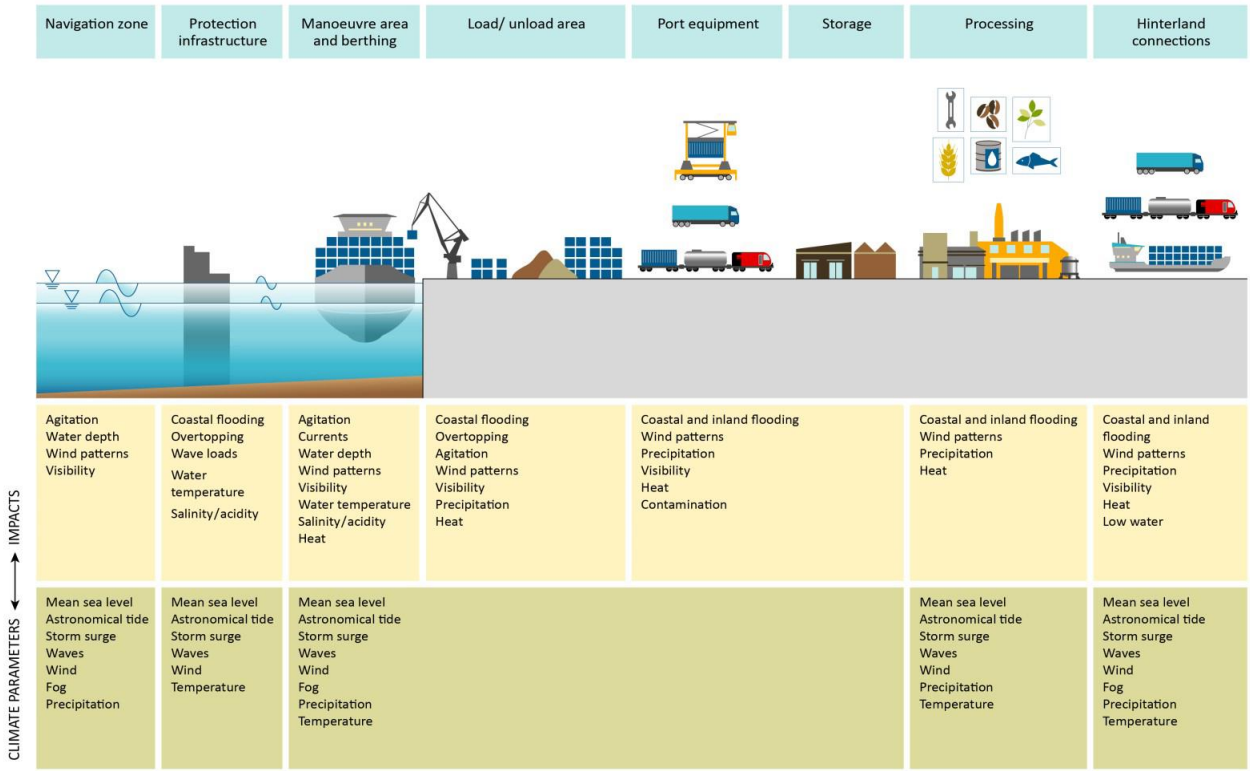
Source: PIANC, 2020

Figure 2: Projection of sea level rise in 2100 along the coast of Malaysia

4.2 The sea level projection for every 10-year interval from 2020 until 2100 shows an ascending trend over time. NAHRIM has recommended that a greater integration of the scientific, engineering, socio-economic and political agenda should be pursued to produce the best solutions for the climate change issues. Disasters can be mitigated with knowledge and preparedness.

5.0 IMPACTS

5.1 Extreme weather and climate change policy failures were identified by the World Economic Forum's Global Risk Report in 2019 as the gravest short to medium-term threats to be dealt with globally. Without timely and effective preparation, climate change will result in increasing incidences of damage or structural failures; leading to disruption in socio-economic activities and impact on the safety of the public, equipment and the environment. Figure 3 illustrates where changes in climate parameters or processes can lead to such impacts to a port, a vital infrastructure to Malaysia's economy. This is also applicable to other economic activities.



Source: PIANC, 2020

Figure 3 Interactions between climate parameters and processes and representative port assets and operations

5.2 Vulnerability of a coastline subjected to sea level rise can be measured through three components, i.e. physical, social and economic vulnerability. Table 1 shows a summary of vulnerability and capacity factors being considered in this analysis (Rahayu *et al*., 2019).

Table 1: Vulnerability and capacity factors for a coastline subjected to sea level rise

Factor	Index Parameter
Physical vulnerability	
Dominant land use	Regions dominated by built environment will be at higher risk of sea level rise
Coastline	Regions with closer proximity to the sea or open water bodies have higher vulnerability
Critical facilities	Regions that has more critical facility in terms of importance and scale of services have higher vulnerability
Social vulnerability	
Projected population density	Higher population density leads to higher vulnerability
Education level	Population with lower education level leads to higher flood vulnerability
Poverty level	Regions with higher ratio of population below poverty line has higher vulnerability
Vulnerable group	Infants/toddlers, elder and disable population are more vulnerable
Economic vulnerability	
Land value/price	Higher-priced land has higher vulnerability
Capacity	
Programme continuity	Existence of any intervention programmes increases the capacity level
Community involvement	Community involvement in intervention programmes increases the capacity level
Program success	Programmes that show evidence of lowering hazard or vulnerability increases the capacity level

(Adapted from Rahayu *et al*., 2019)

5.2 In 2019, Bank Negara Malaysia (BNM) considered climate change as a material source of risk that could pose threats to financial stability (Table 2). The risk can be sub-categorized as physical risk, transition risk and liability risk arising from climate change of which, sea level rise is a factor.

Table 2: Types of climate-related risks and its impact

	Description	Impacts
Physical risk	Direct impacts of climate-related events to assets, financials, earnings or reputation: - Changing weather patterns - Sea level rise - Extreme weather events - Climate induced natural disaster	- Damage to physical assets or devaluation of financial assets/investments - Early retirement or abandonment of assets - Reconstruction/replacement of damaged infrastructure - Wider economic deterioration (lower demand, productivity and output) - Disruption to business operations, trade and supply chain - Lower household and business income - Displacement or forced migration - Increase in insurance premiums and takaful contribution as well as higher than expected insurance/takaful claims
Transition Risk	Disruption from adjustment to low-carbon economy: - Policy changes and legal reforms - Political orientation - Scientific breakthrough and technological innovation - Market sentiment and consumer preferences - Social activism	- Stranded, obsolescence, or unanticipated write-downs of assets - Asset replacement costs - Revaluation of financial assets - Threat to viability of business - Higher business operation cost - Impact on pricing and demand - Increase in default risk
Liability Risk	Legal cost and claims incurred as a result of not considering or responding to the impacts of climate change - Stakeholder litigation - Regulatory enforcement	- Penalties resulting from litigation action - Business disruption or cessation of business operations

Source: BNM, 2019

5.3 Sea level rise increases tidal levels causing inter-tidal land to become narrower resulting in a coastal squeeze. Inter-tidal land is the natural habitat for many species of flora such as mangroves. Mangroves are hosts to various species of aquatic life such as fish and prawn. Longer inundation times, alteration of the saltwater-freshwater mix and natural competition within the more constrained inter-tidal space will have negative effects on the habitats.

5.4 Larger waves are able to travel further inshore before breaking with increased sea level. The increased energy will heighten the risk of beach erosion. Coastal defence structures that protect the coast against flooding and erosion will be also have a higher risk of being overtopped. Coastal homes, resorts and public amenities will be

exposed to higher risk of erosion particularly if they are currently unprotected.

5.5 Recreational space will be reduced as tides reach further inshore. Beaches will become narrower during high tide while amenities are forced to be built further inland beyond the reach of the advancing tides and waves.

5.6 NAHRIM has studied sea level rise projection along the coast of Klang and Kuala Langat districts in Selangor. Sea level is projected to rise up to 2 m above MSL, which impacts about 62 ha of urban settlement based on IPCC Assessment Report No. 4 (released in 2007). Other expected impacts are increased tidal heights, higher erosion risks to the inner section of waterways, siltation of mangroves, inundation of jetties, public utilities and settlements. About 90% of the affected areas are mangrove areas (NAHRIM, 2015).

6.0 ENGINEERING INTERVENTION

The required engineering response is primarily the need to increase the factor of safety for existing coastal and maritime structures. Against the threat of inundation, the crest level of coastal protection structures needs to be raised. The operating levels of jetties, berths need to be raised. Timely upgrades of coastal defences is needed. This must be carefully integrated into current and future coastal development plans since inappropriately designed or phased coastal works could severely affect adjacent coasts.

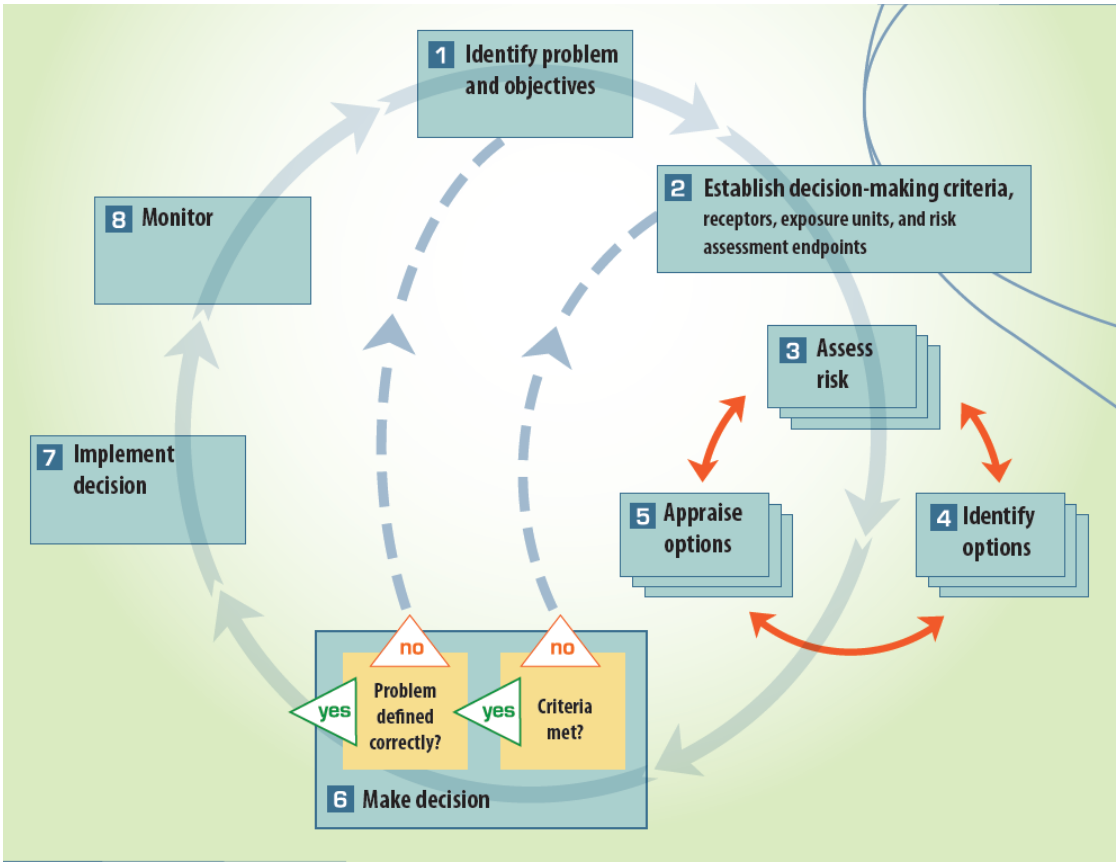
7.0 ADAPTATION MEASURES

7.1 There are generally two types of adaptation i.e. "reactive" and "planned." Reactive responses are actions that are taken after impacts have already occurred. Reactive response can include rebuilding restrictions, requirements that rebuilt structures be retrofit to be more resilient to impacts and buyouts of land with damaged structures. Reactive responses also frequently utilise structural solutions. Planned adaptation is intentional and proactive. It involves advance planning and implementation of measures that are designed to pre-emptively mitigate negative consequences from natural hazards and human responses to those hazards. By engaging in proactive planning, the use of non-structural solutions to protect against risks can be facilitated. Non-structural solutions include using land-use measures to ensure that development is more resilient to flooding and erosion and reduce the cost and difficulty of a long-term retreat strategy. Proactive non-structural solutions are often more cost effective over the long term and less environmentally damaging than reactive responses (USAID, 2009). Pre-empting coastal erosion has already been conducted through the preparation of Integrated Shoreline Management Plans.

7.2 Capacity to respond to climate change issues will develop with time, experience and positive reinforcement that come with success. Adaptation may be simpler with establishing setbacks and buffer areas (in undeveloped areas or areas proposed for future development) that are exposed to flooding and erosion. The current setback distances should be reviewed with respect to the sea level rise projections.

7.3 More complex adaptation measures might include those that involve infrastructure development and maintenance. Population density and infrastructure are other key considerations in selecting an appropriate measure. The current favoured adaptation option in developed areas would be structural coastal protection to stabilise the coastline. In underdeveloped areas, a strategy of retreat (relocating the population and development by "retreating" landward i.e., away from the potential risk) could be applied. Using a single, stand-alone measure is usually not the best approach. To respond effectively to a wide array of climate change (where sea level rise is a major parameter) impacts requires combining complementary measures. This contributes to good coastal management bringing additional benefits in terms of climate change adaptation. A list of potential measures that can be undertaken as part of a suite of complementary adaptation actions for a particular climate change issue or adaptation goal is provided in Table A of the *Appendix*.

7.4 The proposed process policymakers can adhere to in developing climate adaptation plans is shown in Figure 3. A Tool Kit will help policymakers and decision makers to identify the options to consider. It also will help them begin to choose between options and determine which tools to implement in their particular local context. Table B in the *Appendix* is designed to give policymakers a framework for evaluating adaptation options. The costs and benefits and feasibility of a particular tool will vary based upon the particular geographic, political, and legal characteristics of the jurisdiction implementing the tool. A tool that faces obstacles in one community may be supported in another. Therefore, decision makers will need to evaluate each tool within their own particular local context. Each tool is identified based upon the type of goal it would promote i.e. protection, accommodation, retreat or preservation. The Tool Kit introduces state and local government decision makers to some of their policy options as they consider how to adapt built environments to SLR impacts (Georgetown Climate Centre, 2011).



Source: Georgetown Climate Centre, 2011

Figure Decision-making framework for climate adaptation

8.0 RECOMMENDATION

8.1 Four general principles that can be used in addressing sea level rise in the coastal zone are (CCC, 2018):

8.1.1 Use science to guide decisions;

8.1.1.1 Acknowledge and address sea level rise in planning and permitting decisions.

8.1.1.2 Use the best available science to determine locally-relevant and context-specific sea level rise projections for all stages of planning, project design and permitting reviews.

8.1.1.3 Recognise scientific uncertainty by using scenario planning and adaptive management techniques.

8.1.1.4 Use a precautionary approach by planning and providing adaptive capacity for the higher end of the range of possible sea level rise.

8.1.1.5 Design adaptation strategies according to local conditions and existing development patterns.

8.1.1.6 Conduct maintenance and upgrading of existing coastal protection structures.

8.2 Minimise coastal hazards through planning and development standards;

8.2.1 Avoid significant coastal hazard risks to new development where feasible.
8.2.2 Minimise hazard risks to new development over the life of authorised structures.
8.2.3 Minimise coastal hazard risks and resource impacts when making redevelopment decisions.
8.2.4 Account for social and economic needs of the people.
8.2.5 Ensure property owners understand and assume the risks and mitigate the coastal resource impacts of new development in hazardous areas.

8.3 Maximise protection of public access, recreation and sensitive coastal resources; and

8.3.1 Provide maximum protection of coastal resources in all coastal planning and regulatory decisions.
8.3.2 Maximise natural shoreline values and processes while avoiding expansion and minimise coastline armouring.
8.3.3 Recognise that sea level rise will cause the public land boundary along the coast to move inland. Protect public land and resources as sea level rises. New coastal protection structures should not result in the loss of public land.
8.3.4 Address other potential coastal resource impacts (on wetlands, habitat, agriculture, etc.) from hazard management decisions.
8.3.5 Address the cumulative impacts and regional contexts of planning and permitting decisions.
8.3.6 Require mitigation of unavoidable coastal resource impacts related to permitting and shoreline management decisions.
8.3.7 Consider best available information on resource valuation when mitigating coastal resource impacts.

8.4 Maximise agency coordination and public participation.

8.4.1 Coordinate planning and regulatory decision making with other appropriate local, state, and federal agencies; support research and monitoring efforts.
8.4.2 Conduct vulnerability assessments and adaptation planning at the regional level.
8.4.3 Provide public participation in planning and regulatory processes.

8.5 IEM hereby recommends the following;

8.5.1 SLR safety factors shall be established and applied in engineering design particularly in:
8.5.2 Determining the design water depth in designing crest levels of coastal structures (including width for beach nourishment) and armour rock sizes required to withstand wave energy.
8.5.3 Determining platform levels of jetties, waterfronts and berths.
8.5.4 Analysis of tidal effects on river flooding.

8.6 Planners and local governments should consider a future scenario of higher erosion risk for unprotected shorelines where:

8.6.1 New development should be pre-empted from erosion threats by the application of adequate development setback.
8.6.2 Coastal forests are preserved for their natural ability to attenuate wave forces.
8.6.3 Coastal sand dunes that serve as a long term reserve of beach sand be preserved and not be entirely engulfed by the development footprint.
8.6.4 Local governments adjacent to the shore should endeavour to understand and enforce development setbacks and measures to pre-empt coastal erosion.

8.7 The economics of engineering intervention should be weighed carefully against the benefits of prudent land-use planning; and

8.8 Disaster management must be enhanced through the following:

8.8.1 Coastal hazards and coastal vulnerability are to be adequately mapped.
8.8.2 Improved communication of impending disaster to the public.
8.8.3 Provision of emergency response plans in high risk areas.

THE POSITION PAPER COMMITTEE

Dato' Ir. Nor Hisham bin Mohd Ghazali
Ir. Jaflus bin Abdul Jalil
Ir. Iwan Tan bin Sofian Tan
Prof Ahmad Khairi bin Abdul Wahab
Ir. Mohd. Radzi bin Abd. Hamid
Ir. Nor Aslinda binti Awang
Ir. Norzana binti Mohd. Anuar

REFERENCES

Bank Negara Malaysia. 2019. Climate Change and Principle-based Taxonomy Discussion Paper.

California Coastal Commission (CCC). 2018. California Coastal Commission Sea-level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea-level Rise in Local Coastal Programs and Coastal Development Permits.

Delaware Coastal Programs. 2012. Preparing for Tomorrow's High Tide Sea Level Rise Vulnerability Assessment for the State of Delaware. Delaware Department of Natural Resources and Environmental Control.

Department of Irrigation and Drainage. 2015. National Coastal Erosion Study for Malaysia 2015.

Georgetown Climate Center, 2011. Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use – How Governments Can Use Land Use Practices to Adapt to Sea-Level Rise.

IPCC, 2019: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)].

McInnes, K.L., Church, J.A., Zhang, X., Monselesan, D. and Legresy, B. 2017. Sea-level Rise Projections for Malaysia: Final Report for NAHRIM, Malaysia.

National Hydraulic Research Institute Malaysia (NAHRIM). 2017. Impact of Climate Change- Sea Level Rise Projections for Malaysia.

National Hydraulic Research Institute Malaysia (NAHRIM). 2015. Unpublished. The study on impact of sea level rise to the planning and development of National Coastal Zones – Case Study: Klang, Selangor Darul Ehsan. Amri Md. Shah, Mohd Radzi Abd Hamid, Md. Khairi Yaacob, Nor Aslinda Awang, Wan Ahmad Hafiz Wan Ahmad Azhary, Yannie Anak Benson, Siti Salihah Mohd Sendek, Mohamma Faizan Sahinin. NAHRIM.

PIANC. 2020.Climate Change Apdatation Planning for Ports and Inland Warterways. EnviCom WG Report no. 178 – 2020.

PLANMalaysia. 2019. Rancangan Fizikal Zon Persisiran Pantai Negara 2: Terma Rujukan.

Rahayu, H., Haigh, R., Amaratunga, D., Kombaitan, B., Khoirunnisa, D. and Pradana, V. 2019, "A micro scale study of climate change adaptation and disaster risk reduction in coastal urban strategic planning for the Jakarta", International Journal of Disaster Resilience in the Built Environment, Vol. 11 No. 1

USAID 2009. Adapting to coastal climate change: A guidebook for development planners. The U.S. Agency for International Development Global Climate Change Team Washington, DC, USA.

APPENDIX

Table A: Adaptation Measures, Goals, And Climate Change Impacts.

Adaptation Measures	Description	Relevance to Climate Change
FUNCTIONING AND HEALTHY COASTAL ECOSYSTEMS AS A PRIMARY GOAL		
Coastal wetland protection and restoration	Provides nursery habitats for fisheries, ecosystems services for communities and their livelihoods; serves as a natural water filter; buffer against coastal ecosystems. Climate change mitigation and adaptation measure.	Acts as buffer against extreme weather events, storm surge, erosion, and floods; limits salt water intrusion.
Marine conservation agreements	Formal or informal agreements between parties to exchange benefits, take or refrain from certain actions, transfer certain rights and responsibilities in order to restore and protect fragile coastal and marine ecosystems.	Improves the resilience of coastal ecosystems to climate change and improves the economic and social conditions of coastal communities.
Marine protected areas	Intertidal or subtidal terrain areas, their waters, flora, fauna, and cultural and historical features, of which part or all is protected. An overarching management approach or strategy that can be used to bundle a series of measures.	Maintains healthy and resilient coastal habitats and fisheries productivity; acts as "refugia" and critical sources of new larval recruits.
Payment for environmental services	Financial instruments under which beneficiaries of ecosystem services compensate the suppliers as a means to fund sustainable environmental management policies and actions. No-regrets option.	Provides incentives to protect critical habitats that defend against damages from flooding and storm surges as well as coastal erosion.
BUILT ENVIRONMENT IS LESS EXPOSED AS A PRIMARY GOAL		
Beach and dune nourishment	Process of adding sand to enlarge and enhance coastal beach and dune features as well as, in many cases, planting grasses and native vegetation. Level and rate of nourishment can be adjusted to adapt to rising sea levels.	Protects shores and restores beaches; serves as a "soft" buffer against flooding, erosion, scour and water damage.
Building standards	Delineate the minimum technical and safety requirements for the design and construction of residential and commercial structures as a means to promote occupant health, welfare and safety. Can be prescriptive or objective-oriented.	By incorporating climate considerations (e.g. effects of flooding, waves and wind) in building design, it reduces damages and human safety risks from climate change impacts, including extreme events, sea level rise, and flooding.
Coastal development setbacks	Set distance from a coastal feature within which all or specific types of development are prohibited; often includes a buffer. Useful within an overarching coastal management program.	Reduces the infrastructure losses and human safety risks of sea level rise, storm surge, and erosion.
Living shorelines	Management practice involving strategic placement of plants, stones, sand fill and other materials to achieve the dual goal of long-term protection/restoration/enhancement of shoreline habitats and the maintenance of natural processes.	Mitigates erosion and protects people and ecosystems from climate change impacts and variability in low to medium energy areas along sheltered coastlines (e.g. estuarine and lagoon ecosystems).
Structural shoreline stabilization	Shoreline hardening or armoring; ranges from technically complex structures to the placement of construction debris serving as, for instance, bulkheads, revetments and seawalls. Not a long-term strategy, but option of last response.	Temporary buffer against the impacts of erosion and flooding caused by factors such as sea level rise, storm surge, and wave attacks.
DIVERSIFIED LIVELIHOODS AS A PRIMARY GOAL		
Fisheries sector good practices	Adapting fisheries management and strengthening capacity to deal with long-term climate-related effects on relevant habitats and ecosystems. Can apply to production, infrastructure, operations and/or ecosystem protection.	Contributes to the protection of rural livelihoods, food security and marine biodiversity against the impacts of extreme climate events, precipitation change, ocean acidification, sea level rise and sea surface warming.
Mariculture best management practices	Largely self-enforced measures to better efficiency and cost in the mariculture sector in order to increase the derived benefits and promote development.	Integration of climate change considerations helps safeguard against extreme climate events, precipitation change, ocean acidification, sea level rise and sea surface warming.
Tourism best management practices	Actions that enable the tourism sector to improve services and business while minimizing the adverse effects on the environment and local communities. Can serve as climate change mitigation and adaptation measure.	Integration of climate change concerns helps promote the sector's sustainability as well as safeguard against extreme climate events, precipitation change, sea level rise and sea surface warming.
HUMAN SAFETY AND SAFETY ENHANCED AS A PRIMARY GOAL		
Community-based disaster risk reduction	An overarching management approach or strategy consisting of structural and non-structural measures that prevent, mitigate and/or help prepare for the effects of natural hazards. Can be used to bundle a series of measures.	By proactive planning and capacity building that addresses the specific needs of local communities, increases their resilience and ability to respond to the effects of extreme climate events and flooding.
Flood hazard mapping	Conducted in areas adjacent to water bodies to ensure land owners, insurers and regulators have relevant information on flooding risks.	Informs coastal planning processes and policy, reducing the impact of flooding resulting from storm events, heavy rains, storm surges, and extreme tides.
OVERARCHING PLANNING AND GOVERNANCE AS A PRIMARY GOAL		
Coastal watershed management	Integrated water resources management (IWRM) in the coastal context, which takes into consideration watershed and estuary management. An overarching approach or strategy that can be used to bundle a series of measures.	Preserves estuaries, which act as storm buffers and protect against coastal groundwater salinization.
Integrated coastal management	An overarching management approach or strategy involving planning and decision-making geared to improve economic opportunities and environmental conditions for coastal people. Can be used to bundle a series of measures.	Provides a comprehensive process that defines goals, priorities, and actions to address coastal issues, including the effects of climate change.
Special area management planning	An overarching management approach or strategy for a geographic area of critical concern, usually within the context of a coastal resources management program. Can be used to bundle a series of measures.	Improves the management of discreet geographic areas where there are complex coastal management issues and conflicts, including issues related to extreme climate events, precipitation change, ocean acidification, sea level rise and temperature change.

Source: USAID, 2009

Table B: Sea Level Rise Responses And Evaluation Criteria

Potential Responses	Evaluation Criteria			Governance Criteria	
	Economic	Environmental	Social	Administrative	Legal
PLANNING TOOLS					
1. Comprehensive Plans*	✻	✻	✻	✻	✻
REGULATORY TOOLS					
2. Zoning and Overlay Zones*	✻	✻	✻	✻	✻
3. Floodplain Regulations*	✻	✻	✻	✻	✻
4. Building Codes and Resilient Design	~	~	~	~	+
5. Setbacks/Buffers	~	+	~	~	~
6. Conditional Development and Exactions	~	+	+	~	~
7. Rebuilding Restrictions	~	+	~	~	~
8. Subdivisions and Cluster Development	+	+	~	~	+
9. Hard-Armoring Permits	!	!	~	~	~
10. Soft-Armoring Permits	~	~	~	~	~
11. Rolling Coastal Management / Rolling Easement Statutes	~	+	~	~	!
SPENDING TOOLS					
12. Capital Improvement Programs	~	+	~	~	~
13. Acquisitions and Buyout Programs	!	+	~	~	+
14. Conservation Easements	+	+	+	~	~
15. Rolling Conservation Easements	~	~	+	!	!
TAX AND MARKET-BASED TOOLS					
16. Tax and Other Development Incentives	~	+	+	~	~

Advantageous (+)	The tool maximizes benefits and is feasible.
Neutral (~)	The tool may present some disadvantages or some feasibility problems.
Disadvantageous (!)	The tool may be difficult to implement because of costs or infeasibility.

Note:
* Local governments must typically adopt a comprehensive plan and zoning to regulate land use
Source: Georgetown Climate Centre, 2011

Table C: Sea Level Rise Responses By Adaptation Goal

Potential Responses	Goals			
	Protect	Retreat	Accommodate	Preserve
PLANNING TOOLS				
1. Comprehensive Plans	✔	✔	✔	✔
REGULATORY TOOLS				
2. Zoning and Overlay Zones	✔	✔	✔	✔
3. Floodplain Regulations	✔	✔	✔	✔
4. Building Codes and Resilient Design			✔	
5. Setbacks/Buffers			✔	✔
6. Conditional Development and Exactions		✔	✔	
7. Rebuilding Restrictions		✔		
8. Subdivisions and Cluster Development			✔	✔
9. Hard-Armoring Permits	✔	✔	✔	
10. Soft-Armoring Permits		✔	✔	
11. Rolling Coastal Management / Rolling Easement Statutes		✔		
SPENDING TOOLS				
12. Capital Improvement Programs	✔	✔	✔	✔
13. Acquisitions and Buyout Programs		✔		✔
14. Conservation Easements		✔		✔
15. Rolling Conservation Easements		✔	✔	
TAX AND MARKET-BASED TOOLS				
16. Tax and Other Development Incentives		✔	✔	✔