PRIME MINISTER'S DEPARTMENT
ECONOMIC PLANNING UNIT

AKADEMI SAINS MALAYSIA

WST 2040

WATER SECTOR TRANSFORMATION

CLIMATE CHANGE IMPACT AND ADAPTATION (CCIA)

(VOLUME VII)

PRIME MINISTER'S DEPARTMENT
ECONOMIC PLANNING UNIT

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WATER SECTOR TRANSFORMATION 2040

SUB-SECTORAL FINAL REPORT

CLIMATE CHANGE IMPACT AND ADAPTATION (CCIA)

(VOLUME VII)

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Foreword

The Economic Planning Unit (EPU), on 3rd April 2020, appointed the Academy of Sciences Malaysia (ASM) as its strategic partner to undertake the Study on Water Sector Transformation Agenda 2040 (WST2040), to transform the water sector from an enabler to becoming a dynamic growth engine by 2040, as stated in the 12th Malaysia Plan (12th MP). This standalone Volume 7, "Climate Change Impact and Adaptation (CCIA)", forms part of 9 compendia of reports. Volume 1, the Main Report, summarised the output of Volume 2 to Volume 9. The details in Volume 1, can be found in each of the 8 standalone reports.

The emphasis in all these reports is on achieving a secure, sustainable, and vibrant water industry in Malaysia, which aims to forge it into a dynamic, efficient, sustainable, and revenue-generating industry. The five focused areas of WST2040 are empowering people as the drivers of the transformation, strengthening governance, enhancing data-driven decision-making, ensuring sustainable financing and developing sustainable and cost-effective infrastructure. The study, if the recommendations are implemented, will contribute significantly to the national gross domestic product (GDP), create new job opportunities and facilitate the development of science, technology, innovation and economy (STIE), and enhance the research, development, innovation and commercialization (RDIC) of indigenous new product for both the national and global platforms. This transformation agenda is planned over 2 decades and 4 phases of four 5-year Malaysia Plans (MP), starting with 12th MP.

Most of the climate change impact is related to water and thus its impact strongly influences water security. In this regard, CCIA sub-sector study provided inputs to the WST2040 study by framing a national strategy for the adaptation of climate change to enhance adaptive capacity and build resilience, with a specific focus on the impact of 1.5°C global warming in the country. The report delivered by the CCIA sub-sector has detailed key recommendations in strengthening the existing programmes and identifying new short-term (12MP) and long-term (13th to 15MP) initiatives for the strategic transformation of the country's water sector.

To achieve the target of the study, we partnered with expert advisors and researchers from multiple organisations, which were led by UKM. Leveraging on their knowledge and expertise, we were able to produce outputs and recommendations that we believe can help upscale our adaptation initiatives in the country. On behalf of ASM, I would like to take this opportunity to thank the CCIA team headed by Professor Joy Jacqueline Pereira FASc, for all their dedication, hard work, and commitment.
Thank you.

IR. DR. SALMAH ZAKARIA FASc
Chairperson, Project Management Committee WST2040
Water Sector Transformation (WST2040) Study Team, EPU-ASM and
Chairperson, ASM Water Committee, 2015-2021

Preface

The National Agenda for Water Sector Transformation 2040 (WST2040), led by the Economic Planning Unit (EPU), Prime Minister's Department, aims to transform the water sector into a dynamic economy that contributes to the country's Gross Domestic Product and expands employment opportunities, in turn driving the nation's science, technology, and innovation development.

Climate Change Impact and Adaptation (CCIA) is one of the eight sub-sectors that carry out the WST2040 study under the Academy of Sciences Malaysia (ASM) as a strategic partner in collaboration with the EPU. The CCIA sub-sector aims to develop a strategic advisory report to provide inputs to the EPU study and also frame a national strategy for climate change adaptation to enhance adaptive capacity and build resilience, with a specific focus on the impacts of 1.5°C global warming in the country.

Extreme weather events, such as severe heat and rainfall, are expected to become more common as a result of the 1.5°C global warming. This has contributed to an increased risk of disasters, with Southeast Asia expected to experience the largest impacts, especially on economic growth. Inputs from the assessment of literature and review of policies, regional documents, case studies, multiple elicitation techniques and strategic consultation with the stakeholders have resulted in a set of key recommendations based on the five focus areas, namely people, governance, information, finance and infrastructure.

The Twelfth Malaysia Plan has outlined the integration of adaptation and disaster risk reduction as a national strategy to address the climate challenges. The participation and engagement of the key enablers such as KASA and NADMA have ensured that the recommendations submitted to the EPU are aligned with the aspirations of the respective institutions and maintain synergy with the WST2040.

Thank you.

PROFESSOR DR. JOY JACQUELINE PEREIRA FASc
Chairperson
Sub-sector on Climate Change Impact and Adaptation
Water Sector Transformation 2040 (WST2040) Development Study

List of Acronyms

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
ASM	Academy of Sciences Malaysia
ATES	aquifer thermal storage for heating and cooling
BCM	billion cubic meters
BPA	bisphenol A
CCA	climate change adaptation
CCIA	climate change impact and adaptation
CFS2	climate forecast system
CGM	Climate Governance Malaysia
COVID-19	coronavirus disease 2019
CSOs	civil society organisations
CWL	critical water level
DBKL	*Dewan Bandaraya Kuala Lumpur* (City Hall of Kuala Lumpur)
DOA	Department of Agriculture
DRR	disaster risk reduction
EPU	Economic Planning Unit
GCMs	general circulation models
GHG	greenhouse gas
GSM	Geological Society of Malaysia
HORAS	hybrid off-river augmentation system
ICT	information and communications technology
IFM	Integrated Flood Management
IGM	Institute of Geology Malaysia
IMR	Institute for Medical Research
IoT	internet of things
IPCC	Intergovernmental Panel on Climate Change
IRBM	Integrated River Basin Management
IWRM	Integrated Water Resources Management
JAS	*Jabatan Alam Sekitar* (Department of Environment)
JKR	*Jabatan Kerja Raya* (Public Works Department)
JKT	*Jabatan Kerajaan Tempatan* (Local Government Department)
JMG	*Jabatan Mineral dan Geosains* (Department of Mineral and Geoscience Malaysia)
JPS	*Jabatan Pengairan dan Saliran* (Department of Irrigation and Drainage)
KASA	*Kementerian Alam Sekitar dan Air* (Ministry of Environment and Water)
KeTSA	*Kementerian Tenaga dan Sumber Asli* (Ministry of Energy and Natural Resources)

KPIs	key performance indicators
KPKT	*Kementerian Perumahan dan Kerajaan Tempatan* (Ministry of Housing and Local Government)
KPLB	*Kementerian Pembangunan Luar Bandar* (Ministry of Rural Development)
LSANK	*Lembaga Sumber Air Negeri Kedah* (Kedah State Water Resources Board)
LUAS	*Lembaga Urus Air Selangor* (Selangor Water Management Authority)
MAFI	Ministry of Agriculture and Food Industries
MARS	managed aquifer recharge storage
MBPJ	*Majlis Bandaraya Petaling Jaya* (Petaling Jaya City Council)
MESTECC	Ministry of Energy, Science, Technology, Environment & Climate Change
MET Malaysia	Malaysian Meteorological Department
MGTC	Malaysian Green Technology and Climate Change Centre
MHP	multi-hazard platform
MITI	Ministry of International Trade and Industry
MKN	*Majlis Keselamatan Negara* (National Security Council)
MOE	Ministry of Education
MOH	Ministry of Health
MOHE	Ministry of Higher Education
MOHR	Ministry of Human Resources
MOSTI	Ministry of Science, Technology and Innovation
MPAJ	*Majlis Perbandaran Ampang Jaya* (Ampang Jaya City Council)
MPIC	Ministry of Plantation Industries and Commodities
MYD	Malaysian Youth Delegation
myDRR	Malaysian DRR Platform
MYSA	Malaysian Space Agency
MyWP	Malaysian Water Partnership
NADMA	National Disaster Management Agency
NaFFWS	National Flood Forecasting and Warning System
NAHRIM	National Water Research Institute of Malaysia
NAPA	National Adaptation Program for Action
NAPIC	National Property Information Centre
NATECH	natural hazard triggered technological accidents
NAWABS	National Water Balance Management System
NC3	Third National Communication
NCEP	National Centres for Environmental Prediction
NGOs	Non-Governmental Organisations
NGTP	National Green Technology Policy
NLCCMP	National Low Carbon Cities Master Plan
NRE	Ministry of Natural Resources and Environment Malaysia
NSDWQ	National Standard Drinking Water Quality
NWC	National Water Council
NWP	National Weather Prediction
NWRP	National Water Resources Policy

OCPs	organochlorine pesticides
PAEs	six phthalate esters
PLANMalaysia	Department of Town and and Country Planning
RBOs	river basin organisations
RCMs	regional climate models
RDIC	research, development, innovation and commercialisation
RENEW	renewable energy and water
RMK	*Rancangan Malaysia Ke* (Malaysia Plan)
SDG	Sustainable Development Goal
SEADPRI	Southeast Asia Disaster Prevention Research Initiative
SMEs	small and medium enterprises
UKM	Universiti Kebangsaan Malaysia
UM	Universiti Malaya
UMS	Universiti Malaysia Sabah
UN-ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNIMAS	Universiti Malaysia Sarawak
UNISDR	United Nations International Strategy for Disaster Reduction
UPM	Universiti Putra Malaysia
USM	Universiti Sains Malaysia
UTM	Universiti Teknologi Malaysia
UUM	Universiti Utara Malaysia
WST2040	Water Sector Transformation 2040

Acknowledgements

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Malaysian Youth Delegation (MYD)
Geological Society of Malaysia (GSM)
Academy of Risk Management Malaysia
Universiti Malaysia Sabah (UMS)
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Stakeholders

Key Agency
Ministry of Environment and Water (KASA)
National Disaster Management Agency (NADMA)
Department of Irrigation and Drainage (JPS)
Malaysian Meteorological Department (MET Malaysia)
Department of Mineral and Geoscience Malaysia (JMG)
National Water Research Institute of Malaysia (NAHRIM)
Ministry of Energy and Natural Resources (KeTSA)
Malaysian Green Technology and Climate Change Centre (MGTC)
Federal Department of Town & Country Planning (PLAN Malaysia)
Ministry of Health (MOH)
Institute for Medical Research (IMR)
Department of Fisheries (DOF)

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Executive Summary

Global warming of 1.5°C is projected to intensify extreme weather events, including severe heat and rainfall that contribute to increased risk of disasters, with Southeast Asia projected to experience the largest impact on economic growth. Climatic hazards ranging from fast onset floods and landslides to slow onset events such as salinisation and pollutant mobilisation are expected to intensify, amplifying existing threats and creating new risks to vulnerable populations and exposed assets and supply chains. Water related hazards will have a cascading effect on food security and agriculture, coastlines, forests and biodiversity, public health and the built environment.

Climate change risk, impact and vulnerability assessment are best conducted at the river basin or local scale in conjunction with operational agencies. Climate models are indicative and should be used judiciously for decision-making at these scales to avoid maladaptation. Process oriented approaches that integrate disaster risks, in conjunction with multi-disciplinary observation, monitoring and early warning, as well as stakeholder engagement is recommended. A step-wise approach will enable the identification of near-term disaster risk reduction and long-term climate change adaptation options, which are prudent and more affordable.

Inputs from the assessment of literature and review of policies, regional documents, case studies, multiple elicitation techniques and strategic consultation with stakeholders have resulted in the following recommendations:

- Enhancing community engagement and capacity in disaster management
- Empowering people for strengthening adaptive capacity to climate change
- Strengthening technical capacity within operational agencies at the river basin level
- Strengthening governance and partnerships at all levels
- Adopting integrated approaches for climate adaptation and disaster risk reduction
- Strengthening regional linkages on disaster risks, climate change and IWRM
- Implementing evidence-based and risk-informed actions
- Enhancing capability for data driven decision making
- Assimilating knowledge to improve planning and implementation
- Investing in disaster risk management
- Strengthening financial capacity for climate resilience
- Enhancing early warning systems and disaster response
- Developing sustainable infrastructure with cost effective technology
- Enhancing disaster preparedness and recovery
- Enhancing conservation measures as an adaptation option for coastal and marine areas

The recommendations have been transformed into a Roadmap with programmes, initiatives, activities, budget and key performance indicators for the immediate-term (12th MP) in conjunction with government agencies. Additional recommendations have been identified for the near-term (13th MP), medium-term (14th MP) and long-term (15th MP). The Roadmap is a living document, to be reviewed and updated where and when necessary throughout the coming years to 2040 by NADMA and KASA in conjunction with the EPU.

1.0 INTRODUCTION

The National Agenda for Water Sector Transformation 2040 (WST2040) aspires to transform the water sector to an economy that is dynamic, contributes more significantly to the country's Gross Domestic Product and enhances employment opportunities, while indirectly driving the development of the nation's science, technology and innovation. WST2040 will commence with the 12th Malaysia Plan in 2021 (GoM, 2021). The Economic Planning Unit (EPU), Prime Minister's Department has appointed the Academy of Sciences Malaysia (ASM) as its strategic partner to undertake a study to further develop WST2040.

The mainstreaming of climate change is reflected in national development policies and strategies. The current development narrative for Malaysia, as embodied in the Shared Prosperity Vision 2030, has three objectives underpinned by 15 guiding principles and 8 enablers covering 7 strategic thrusts 15 key economic growth activities (Ministry of Economic Affairs Malaysia, 2019). Climate change comes under the Strategic Thrust on Social Capital. There are several key economic growth activities that are linked to climate change including renewable energy, green economy, logistic, transportation and sustainable mobility. A total of ten economic indicators and eight social indicators have been identified to measure progress and one of these is the environmental and climate change index. The Shared Prosperity Vision 2030 builds on existing climate change measures in the country.

The National Policy on Climate Change was formulated in 2009 to address the challenges of climate change in an effective and holistic manner and promote balanced adaptation and mitigation, including disaster risk reduction, to achieve climate resilient development (Government of Malaysia, 2010). Climate change mitigation is mainstreamed in the country with a national aspiration to reduce GHG emission intensity of Gross Domestic Product by up to 40 percent of 2005 levels by 2020 with financial support (MESTECC, 2018). This pledge has been made more ambitious recently with an entirely voluntary reduction of GHG emission intensity of Gross Domestic Product by up to 45% in 2030 compared to 2005 levels (GoM, 2021; KASA, 2021). The carbon intensity would be calculated based on emissions of seven greenhouse gases, which include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbon (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF3) (KASA, 2021). Climate change adaptation is embedded in specific sectors through existing environmental management plans, national conservation strategies, disaster management plans as well as in programmes of other sectors such as agriculture, forestry, transportation and fisheries, among others. The 12th Malaysia Plan has outlined the integration of adaptation and disaster risk reduction as a national strategy (GoM, 2021).

Malaysia is actively addressing the challenges of climate change on various platforms. The country is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and had submitted the Third National Communication (NC3) in 2018, where the Ministry of Environment and Water (KASA) serves as the National Focal Point. Through the National Disaster Management Agency (NADMA) Malaysia, the country reports progress on the Sendai Framework for Disaster Risk Reduction to the United Nations Office for Disaster Risk Reduction. The Economic Planning Unit of the Prime Minister's Department leverages on both these processes to report on the country's progress towards Sustainable Development Goal (SDG) with respect to climate change mitigation, climate change adaptation and disaster risk reduction.

2.0 OBJECTIVES

The Task Force on Climate Change Impact and Adaptation (CCIA) will develop a strategic advisory report to provide inputs to the EPU Study and also frame a national strategy for climate change adaptation to enhance adaptive capacity and build resilience, with specific focus on the impacts of 1.5°C global warming in the country. The specific objectives are as follows:

- Taking stock of the expected impacts of 1.5°C global warming to prioritise key sectors and vulnerable populations as well as its linkages to water resources;
- Identifying key priority actions for strengthening climate change adaptation and enhancing integration with disaster risk reduction in Malaysia, using the best available science;
- Leveraging on IWRM, to identify potential innovation in water technology to integrate climate change adaptation and its co-benefits as well as disaster risk reduction.

The composition of CCIA comprises members who are researchers from universities, enablers from agencies and the private sector, as well as co-opted contributors and partners (**Table 1**). The enablers have the capacity to facilitate the uptake of recommendations into existing governance systems and processes for implementation. The participation of key enablers such as KASA and NADMA is vital to ensure that the recommendations submitted to the EPU are aligned with the aspirations of the respective institutions and maintains synergy with WST2040. The Task Force is supported by an ASM Senior Analyst, ASM Analyst and ASM Research Assistant, as well as Subject Matter Experts appointed by the ASM.

Table 1 The ASM Task Force on Climate Change Impact and Adaptation

Researchers:	Government and Private Sector Enablers:
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15. Malaysian Youth Delegation (MYD)
16. Geological Society of Malaysia (GSM)
17. Academy of Risk Management Malaysia
18. Universiti Malaysia Sabah (UMS)
19. Universiti Malaysia Sarawak (UNIMAS)
20. Universiti Putra Malaysia (UPM) Campus Bintulu, Sarawak

3.0 SCOPE OF STUDY

The scope of the Task Force is in line with the Terms of Reference for the EPU Study (**Table 2**). The Task Force is designed to ultimately result in a Roadmap for 1.5°C Global Warming to 2040. All activities have been completed and the deliverables from the six scopes have resulted in the Roadmap (**Figure 1**). The specific deliverables are as follows:

- Review of Scientific Literature and National Policies (Scope 1): This deliverable is essentially a synthesis of the status of knowledge on climate change impacts and policy analysis, to delineate gaps and recommendations;
- Comparative Analysis (Scope 2): This deliverable documents climate change adaptation strategies and technology related to IWRM and water management in ASEAN, which aims to provide insights on the country's competitive edge for making the country a regional water hub;
- Case study of Selangor River Basin (Scope 3): This deliverable delineates context and basin specific priority actions on climate actions for water security, focusing on surface and groundwater resources;
- Focus group discussions and survey (Scope 4): This deliverable captures a range of perspectives on priorities from multiple stakeholder groups such as experts, the private sector, youths and the community;
- Stakeholder engagement (Scope 5): This deliverable encompasses recommendations that are integrated from multiple sources including peer reviewed literature, national policies, reports and a variety of engagement sessions; organised according to five focus areas of (i) people, (ii) governance, (iii) information and research, development, innovation and commercialisation (RDIC), (iv) finance and (v) infrastructure and technology; and
- Integration of recommendation on climate action (Scope 6): This deliverable constitutes the Roadmap that comprises strategies, programmes and initiatives, activities, etc. for the immediate-term (12th MP), near-term (13th MP), medium-term (14th MP) and long-term (15th MP), which have been selected by the custodian ministries and agencies.

Table 2 The Scope of Work of the Task Force on CCIA in the Context of the EPU Study

Term of Reference for the EPU Study on WST2040	Climate Change Impact and Adaptation (CCIA)
Review and Analyse Current Policies with a View to Improvement	Review and analyses of peer reviewed scientific literature and government policies with a view for improvement.
Undertake Comparative Strategy Analysis/Business Models with Other Nations	Content analysis of documents from multi-lateral regional agencies to get an insight on climate change adaptation linkages to IWRM, water management strategies and technology in ASEAN.
Study Potential of the Nation's Water Sector Industry Taking into Consideration Current Global Markets Towards Making the Water Sector as a Dynamic New Economic Sector Capable of Driving the Nation's GDP Growth in the Future	Case studies for prioritisation of climate-impacted sectors related to water, with focus on vulnerable populations, resources, innovative approaches, technology and knowledge gaps.
Prepare a Transformation Strategy and Initiative Implementation Framework for Each of the 4 Phases including the Implementing Agencies, Estimated Budgets and Main Target Achievements Based on the Analyses Undertaken and Expert Reviews	Focus group discussions, surveys and interviews, to obtain insights on impacted sectors and understand the perception of key stakeholders in setting climate change priorities and targets for the water sector, in line with the four phases of WST2040
Undertake Consultations with Stakeholders and Experts with the Aim to Finalising the Proposed Strategies and Initiatives of the Nation's Water Sector Transformation	Strategic consultative workshops targeting key stakeholders from the federal, state and local levels, private sector, NGOs, etc., to confirm climate change priorities and key actions related to the water sector.
Prepare a Complete Roadmap for the National Agenda on the Water Sector Transformation 2040 for the various Ministries' and Agencies' Information and Guide for the Implementation of Programmes and Activities towards Achieving the Targeted Transformation Objectives	Integration of recommendations on climate actions relevant to the water sector into the four phases of WST2040, as an entry point for framing a national strategy for climate change adaptation.

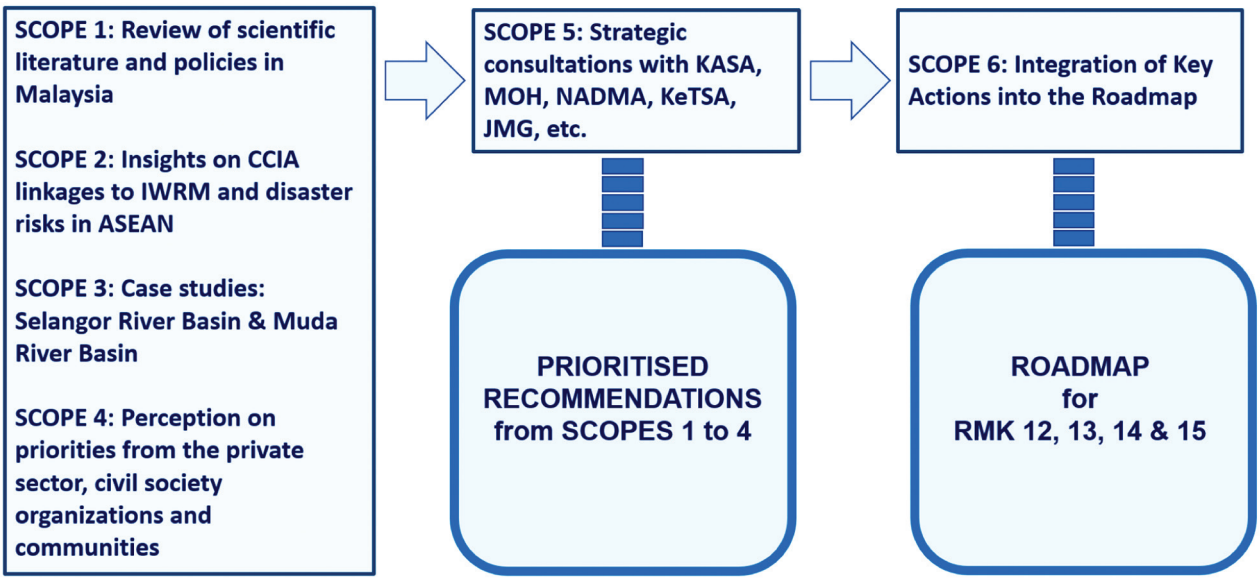


Figure 1 Overview of the Project Scope that Results in the Roadmap for 1.5°C Global Warming to Support the National Agenda on Water Sector Transformation 2040

4.0 IMPACT OF THE COVID-19 PANDEMIC

The COVID-19 pandemic has impacted the study by limiting face-to-face interactions. Communication with government agencies was hampered with delays in securing information. Actions were taken to conduct a majority of the engagement online. Expert engagement workshops were replaced with a series of online bilateral meetings, which enabled substantial in-depth discussions. Stakeholder consultation workshops saw a higher level of involvement as there was no limit to the number of participants. Only one local level engagement i.e., the Citizens Assembly was conducted physically while the others were conducted virtually.

5.0 KEY FINDINGS

The CCIA Task Force met on a monthly basis to discuss the plan of work based on the scope of the study as specified in the Terms of Reference. Preliminary findings were also reviewed to provide guidance to the researchers. A total of 18 Task Force meetings were held during the study. A peer-review community was also established comprising researchers who met between Task Force meetings, to review findings of the assessment of the scientific literature and policies as well as content analysis and survey results. A total of 36 informal peer-review sessions were held during the study.

5.1 Review of Scientific Literature and Policies (Scope 1)

The assessment of the peer reviewed scientific literature was conducted to get an insight into the expected impacts of 1.5°C global warming in Malaysia. The analysis of national policies was done to get an overview of the coverage of climate change issues and actions planned to strengthen climate change adaptation in the country.

5.1.1 Science Perspective

The approach taken is based on causality, where key climate factors give rise to a range of hazards with the potential to impact a variety of sectors (**Figure 2**). The principal climate parameters considered are temperature, rainfall and sea level rise. These give rise to hazards that are driven by climate variability and weather extremes in the short term as well as climate change in the long term. The hazards span from fast onset events such as floods and landslides, to slow onset and insidious incidents such as salinisation and pollutant mobilisation. The sectors are categorised according to five broad themes, three of which are sector-based (ecosystems and services, health and wellbeing, and the built environment) and two that are cross-sectoral (governance and socio-economic). The approach taken allows for better understanding of the causal factors that impact the water sector as well as the interactions of the sector to food security and agriculture, coastlines, forests and biodiversity, public health, and the built environment. In assessing the scientific literature, the focus has been to conduct a systematic analysis of observation and projection of impacts as well as selected adaptation options in key thematic areas.

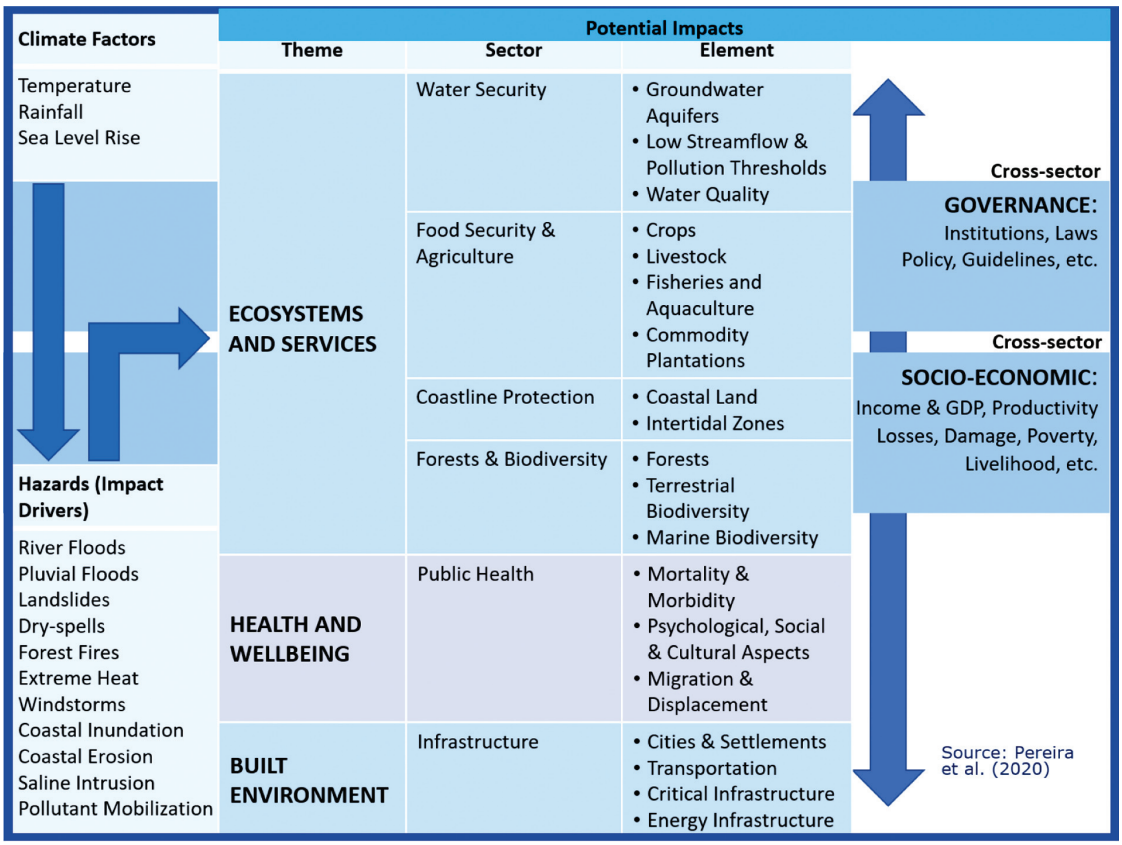


Figure 2 The Approach Taken for the Scientific Assessment

5.1.1.1 Climatic Change and Best Available Science

There is undisputed evidence that the earth has been warming since 1900 and contributing to sea level rise (IPCC, 2021). The world is currently experiencing the consequences of 1.1°C of global warming through more extreme weather, rising sea levels and diminishing Arctic Sea ice, among other changes. With global warming of 1.5°C, Southeast Asia is one of the regions projected to experience the largest impact on economic growth (IPCC, 2018). In this prognosis, there is a higher number of hot days and heavy rains, higher risks of floods, as well as net reductions in yields and nutritional value of rice. The population that is both exposed and susceptible to poverty, particularly those dependent on agriculture and coastal livelihood, is expected to increase in a 1.5°C world.

Downscaled global climate change models have uncertainties that are consistently greater than the uncertainty from hydrological modelling (Stuart et al., 2011). Recent improvements have enabled impact assessment under different scenarios, for example on landfills (Beavan et al., 2020). Unfortunately, Southeast Asia does not have downscaled climate change models of adequate accuracy to conduct similar assessments at the river basin or local scales (Tangang et al., 2012; IPCC, 2013; Cruz et al., 2017; Galavi et al., 2019; Kong et al., 2019; Tan et al., 2019). Downscaled climate models are increasing in the country due to more research but their use is limited by high level of uncertainty due to poor observational records, knowledge gaps and the use of a limited number of general circulation models (Tanggang et al., 2012; Galavi et al., 2019; Tan et al., 2020). This is confirmed by recent findings indicating that precipitation trends in the region are not spatially coherent or consistent across datasets (IPCC, 2021). Climate models in the country need improvement by addressing these issues.

An "end point adaptation" approach that relies on downscaled climate models is not suitable for decision-making. The approach, which relies on downscaled climate models, needs to be improved by contending with and assessing the uncertainties in emission scenarios and pathways, particularly for rainfall. It is imperative that guidelines are developed for where the climate model projections should not be used for decision-making. Expert judgment, scientific understanding, thorough model evaluation, and inclusion multidisciplinary approach should develop a new direction to use the information in operational decision-making.

Despite progress in research, downscaled products from the climate models are unreliable to represent future conditions when they run at a higher resolution, for example, at the river basin level or city scale. Climate models should be used judiciously for decision-making at river basin or local scales, particularly if they are being used to consider adaptation options involving engineered structures such as dams and flood levees. Simulation of extreme weather patterns, in conjunction with inputs from other disciplines, would contribute to support decision-making and reduce the potential for maladaptation when involving engineered structures.

A step wise or "starting point adaptation" approach, which is process oriented, uses climate models indicatively in conjunction with multi-disciplinary observation, monitoring and early warning, as well as stakeholder engagement is the best way moving forward. Climate change risk, impact and vulnerability assessment is an ongoing process. The adoption of a step-wise approach would enable the identification of adaptation options that are prudent and more affordable as infrastructure would age with time and be made obsolete with new technologies.

The step-wise approach requires the identification of weather and climate extremes and its associated risks over time for specific geographic areas, for both fast-events and slow-onset changes influenced by the climate. In this approach, the climate models are indicative and impact models are developed using the best available science from multiple-disciplines to identify areas and communities that will be impacted. This will facilitate the identification of low-regret actions. A regular review of the situation is required as more scientific information becomes available. Systematic efforts are also required to enhance adaptive capacity, build resilience and integrate adaptation into policies, plans and strategies in a coherent manner into various sectors and at the relevant scale. The adaptation options would require a periodic review as more scientific information becomes available.

5.1.1.2 Climatic Hazards and Disasters

Climate factors such as temperature, rainfall and sea level drive a range of geophysical and atmospheric hazards and processes. These include haze, river floods, pluvial floods, landslides, debris flow, subsidence, sinkhole, dry spells, peat fires, heatwave, storms, coastal inundation, coastal erosion, saline intrusion and pollutant mobilisation. These hazards affect both the quantity and quality of surface and groundwater resources, which have implications on water and food security. Poor water security has negative implications on people and ecosystems and gives rise to a variety of socio-economic consequences. The most common hazards in Malaysia are floods, landslides and coastal or riverbank erosion. These hazards are more prominent because they are fast-onset events compared to other hazards such as saline intrusion or subsurface pollutant mobilisation, which tend to be slow albeit insidious and pervasive.

The record of flood events shows that the highest number of events occurred in 2014 (Seadpri-UKM Database, 2020). River floods in that year resulted in about 40 deaths in Kelantan, Sabah and Terengganu. The top three states with the highest number of flood events in nearly two decades are Kelantan, Sabah and Kedah. However, the number of people affected by floods are highest in Sarawak, Pahang and Johor.

The occurrences of pluvial floods in the form of flash floods that result from heavy rainfall are becoming increasingly common, particularly in heavily urbanised areas. In 2015, 58 pluvial floods were recorded, with 25% of the events reported in Kuala Lumpur (Seadpri-UKM Database, 2020). This emerging climate risk has to be better understood in the country and requires a more robust and reliable flood management system at the city level.

Records indicate that coastal inundation has been increasing in recent times, particularly in the west coast of Peninsular Malaysia (Seadpri-UKM Database, 2020). This poses an increasing risk to low lying areas and the population, businesses and infrastructure therein. In 2016, a total of 36 incidences were recorded in Selangor and this is the highest number on record. The state of Selangor is the most developed state in Malaysia and coastal inundation will affect many industries. Thus, such areas need to be delineated so that adaptation planning can be initiated.

Records available in the public domain indicate that in nearly two decades between five and 45 landslides have been reported annually in the country (Seadpri-UKM Database, 2020). The highest number of landslides was reported in 2018. The record indicates that Selangor has the highest number of landslides, followed by Sabah and Sarawak. In 2015, the high landslides distribution in Kundasang and Ranau regions were linked to the rupture of Mw 6.0 earthquake. Fatal landslides in the country include the Highland Towers (Selangor) incident on 11 December 1993 that killed 48 people and the Pos Dipang (Perak) incident on 29 August 1996 where 44 lives were lost. Furthermore, several landslide spots have been identified such as in Cameroon Highland, Kundasang and Ranau. A high number of landslide events has been reported in Kuala Lumpur, which is an indication of the need to develop more sustainable slope designs. Information on landslides, particularly regarding hazards and risk is available in various technical agencies but the public has limited access to this information.

There is an urgent need for open-source data on floods, landslides and other disaster events in the country, specifically regarding the number of events, damages incurred as well as the areas that are susceptible to hazards. Such information is critical for disaster prevention and preparedness to ensure business continuity and build community resilience. This is particularly relevant to cities with densely populated areas and exposed assets, as well as economically important regions for tourism and industrial development, among others. There is also need for detailed sub-surface geological information to better understand the risks of emerging hazards associated with subsurface development, particularly in cities.

5.1.1.3 Climate Change and Groundwater

Water-impacted vulnerable populations will progressively increase at 1.5°C, 2°C and 3°C of global warming, with half of those impacted residing in Asia (IPCC SRCCL, 2019). However, the projections of groundwater recharge using climate models are unreliable due to the uncertainty associated with global scale simulations in addition to geological factors (Smerdon, 2017). To overcome the uncertainties, modelling at a mesoscale between watersheds and continents is suggested. This approach is ideal with multiple climate models. A practical way forward for groundwater management is to continue conducting modelling recharge for the near-term (10-20) years rather than the long timelines associated with climate models. This is especially relevant for the tropics, where the link between precipitation and recharge is direct, depending on rainfall intensity, local geology and abstraction rates (Kotchoni et al., 2018). Locally, it has been found that natural recharge rates could be accelerated by environmentally friendly measures such as distributed recharge methods and managed aquifer recharge methods, leading to an increase in groundwater status (Chinnasamy and Ganapathy, 2018). This makes groundwater a valuable commodity in areas that are currently challenged by poor water services including disruptions. Groundwater is also critical for such areas to manage the impending impacts of climate change (NAHRIM, 2021). Climate change is expected to result in several

challenges specific to groundwater resources. These relate to groundwater availability and the emergence of groundwater hazards.

Groundwater availability will be a major issue in coastal areas due to salinisation of shallow groundwater aquifers (Hoque et al., 2016; Shamsudduha, 2018; NAHRIM, 2021). Shallow unconfined aquifers are more sensitive to climate change than confined and deeper systems (Isokangas et al., 2015; Winter et al., 2017; Havril et al., 2018). Loss of vegetation cover from fires and conversion of land use result in increased runoff and decreased infiltration, reducing groundwater recharge sources (Olivares et al., 2019; Rodrigues et al., 2019).

Groundwater hazards are an emerging threat to shallow infrastructure and coastal ecosystem resilience due to sea level rise that raises coastal water levels (Befus et al., 2020). Water table decline during extended drought periods of more than three months can trigger forest fires in peatland (Susilo et al., 2013). Increases in temperature combined with the effects of El Nino are expected to decrease humidity, increase evapotranspiration, lower groundwater levels, and therefore enhance fire risk in the Asian tropical peatlands. Groundwater levels need to be in the range of 100 cm above and 30-40 cm below peat surface to prevent subsidence and fires (Wösten et al., 2008; Susilo et al., 2013; Putra et al., 2018). Over-exploitation of groundwater resources could result in land subsidence, which has been documented in the region (Phienwej et al., 2006). The hydrological load cycle may impose stress on an underlying fault mechanism, triggering subsidence (Ju-Hsu et al., 2021).

The provision of water services to rural and island communities is a major challenge in parts of Malaysia. Access to water resources from the surrounding treatment plants is limited on Banggi Island, Sabah, the largest island in the country (Mogaji and Lim, 2017). The estimated groundwater use in Malaysia is about 3.4% of the total water consumption in 2010 (MESTECC, 2018). It has been reported that groundwater availability is about 5,000 billion cubic metres (BCM) in comparison to 973 BCM of annual rainfall in the country (ASM, 2017). The potential for groundwater to complement surface resources is an option that merits further investigation in the country, especially where water service is a challenge and disruptions are common. The assessment of the impact of climate variability on groundwater stock to rural and island communities that currently rely on this resource should be a priority.

Sea level rise has been identified as a threat to groundwater resources in the coastal areas of Terengganu, Selangor, Sabah and Sarawak (Jamaluddin et al., 2018; MESTECC, 2018). Local studies on the extent of potential impacts to freshwater availability and quality in these areas are limited. The emergence of groundwater hazards due to sea level rise, especially the potential impacts on coastal infrastructure and ecosystems including peatlands is also an aspect that requires investigation. While human activities and sea level rise are contributing to coastal inundations in Kelantan, studies indicate that tectonic plate movements also play a vital role in vertical land subsidence (Simons et al., 2007; Ahmad and Abdurahman, 2015; Mustafar et al., 2017; Yong et al., 2018). Detailed geological investigation is required to better understand the linkages between groundwater and subsurface conditions.

5.1.1.4 Climate Change, Health and Wellbeing

Over the last century, the increasing frequency and intensity of natural-hazards-turned disasters such as storms, droughts, heat waves and cyclones, caused by the increased temperatures from climate change globally have caused a resurgence of vector-borne diseases such as malaria and dengue, and increase in food and water-borne diseases such as cholera (Seneviratne et al., 2012; Wu et al., 2016). These extreme events, and chain of diseases instigated, have inflicted countless loss of lives, displacements, damages, and socio-economic impacts on human societies (UNICEF, 2015).

Major climate sensitive water borne diseases in Malaysia include cholera, typhoid, dysentery and hepatitis A (Liew and Lepesteur, 2006; Alhoot et al., 2016; Mohd Radi et al., 2018; Abdul Rahim et al., 2020; Hassan et al., 2020). The occurrences of these diseases are exacerbated by the impacts of climate variability and extreme weather events that cause clean water scarcity, coupled with low environmental and personal hygiene, especially at the coastal and riverine areas, and evacuation centres with high population density and crowded environment (Alhoot et al., 2016; Mohd Radi et al., 2018; Abdul Rahim et al., 2020).

Flood events result in the deterioration of river water quality from erosion, sedimentation and accumulation of domestic pollutions including increased heavy metal concentrations (Lim et al., 2019). Contaminated floodwater and sediments contribute to waterborne diseases, especially impacting on young children which sometimes go undetected and lead to worse conditions (Liew and Lepesteur, 2006; Sulaiman, 2016; Hassan et al., 2020). Drainage from sewage has been identified as one of the main source contaminations in well waters (Rahman et al., 2018).

Leptospirosis was also reported during and after the major floods in Kelantan in 2014, especially near garbage dumpsites (Mohd Radi et al., 2018). The highest number of leptospirosis cases in Malaysia was recorded in the eastern state of Kelantan in July 2015, several months after a severe flood in December 2014 (Mohd Radi et al., 2018). Leptospirosis incidences in the post-flood period were more concentrated in urbanised, densely populated, central areas with proximity to garbage accumulation and clean-up sites that provide favourable surroundings for rodents to thrive, thus increasing contact between humans and rodents (Mohd Radi et al., 2018). Water can also be contaminated easily during seasonal floods making it an ideal medium for leptospirosis transmission (Aidid et al., 2018).

Cholera has been reported during prolonged droughts in Sarawak when rural communities shifted their water supply from gravity feed systems and shallow wells, to river water that was contaminated (Liew and Lepesteur, 2006). There is also the possibility that typhoid fever will occur after flood events (Vollaard et al., 2004; Dewan et al., 2013; Davies et al., 2015). This is because surface and groundwater can be contaminated with floodwater during these events (Akpor and Muchie, 2011). *Salmonella typhi* that causes typhoid fever can survive in water and soil for several months. If the groundwater is contaminated with this bacterium during floods, it can be an environmental reservoir for disease transmission (Tran et al., 2005; Md Akhir et al., 2018). Inadequate wastewater management can also increase typhoid fever risk (Saat et al., 2018). Faecal substances contained in septic tank overspills can contaminate floodwaters. As the flood subsides, the remaining water will drain into wastewater drains. If wastewater management is inadequate, the contaminated floodwater might not be drained away and become a stagnant reservoir for *Salmonella typhi* (Md Akhir et al., 2018). In 2015, there was an increase in typhoid disease incidences in northeastern Malaysia following the 2014 flood, at a rate of 10.6 per 100,000 population. This was ten times higher than the national level and the five years median incidence rate. Md Akhir et al. (2018) stated that the lack of clean water and sanitation were the main environmental factors that led to the increased incidences of typhoid fever in northeastern Malaysia during this time.

Besides, increased rainfall increases vector breeding sites of mosquitoes which gives rise to vector borne diseases such as dengue and malaria (Cheong et al., 2013; Alhoot et al., 2019). Climate factors such as temperature, humidity, and precipitation are important for mosquito survival, reproduction, growth, and strength, hence dengue transmission (Shafie, 2008; Er et al., 2011a; Er et al., 2011b; Shafie, 2011; Sahani et al., 2012). Ruzman and Rahman (2017) found that climate factors like rainfall and humidity were the main contributors to dengue cases in Subang Jaya and Sepang in 2013 and 2014. The severe El Niño weather phenomenon that extended dry spell in Malaysia in January 2016 was a major contributor to the 50% increase in dengue cases. This was because the mosquito's life cycle length from egg to adult was reduced to less

than seven days, thus increasing the mosquito population (Sofian, 2016). Normally, the mosquito's life cycle is between 7 to 9 days (Azman and Karim, 2018). A study conducted in several Malaysian states (Hulu Langat and Seremban) found that hot weather and high temperatures accelerate the life cycle of the Aedes mosquito.

5.1.2 Policy Perspective

A review of national policies was conducted to obtain an insight into actions taken to strengthen climate change adaptation in the country. The review was done to delineate the number of measures such as strategies, actions and initiatives across several broad themes related to climate change. The themes encompassed climate change mitigation, climate modelling, disaster risk reduction, surface water security, groundwater security, food security, agriculture, coastal protection, forests and biodiversity, infrastructure, health and wellbeing, socio-economics and governance. A total of 63 national policies, including action plans, master plans, blueprints and frameworks were reviewed, and of these, 43 were found to have measures related to climate change (**Figure 3**). The current analysis is limited, since there are many policies that only provide policy direction and interventions for Peninsular Malaysia. Sabah and Sarawak have a dedicated set of policy instruments that contribute to climate change adaptation and disaster risk reduction but this is beyond the scope of this study.

The National Policy on Climate Change has coverage of climate actions across all the themes. Several policies has measures in at least five themes related to climate change. These include the Green Technology Master Plan, National Physical Plan-3, National Policy on the Environment, National Policy on Science, Technology & Innovation, Malaysia Smart City Framework, National Action Plan for Peatlands, National Water Resources Policy, Second National Policy on Urbanisation, National Policy on Rural Development, National Policy on Forestry, Low Carbon Cities Framework, National Low Carbon Cities Masterplan and National Security Policy, among others.

The National Policy on Climate Change and National Water Resources Policy states several measures related to water security and services, which covers groundwater. Additionally, there are 11 national policies that have measures on water security. Several of these explicitly mention groundwater, including the National Water Resources Policy, National Agrofood Policy, Green Technology Master Plan, National Policy on the Environment, National Policy on Science, Technology & Innovation, National Physical Plan-3 and Malaysia Smart City Framework. Given the importance of water security, four initiatives to be funded by the Green Climate Fund have been proposed recently (MyWP, 2021). The proposed initiatives cover multiple sectors and will be finalised in consultation with key stakeholders.

There are 19 policies in the country that have measures related to disaster risks with the National Water Resources Policy containing the highest number of actions. The National Action Plan for Peatlands, National Policy on Climate Change, Malaysia Smart City Framework are among the other policies that have measures on disaster risks. The National Policy on Climate Change contains measures on environmental pollution and disaster risks (KA1-ST1, KA13-ST4, KA25-ST6 and KA28-ST7), but emerging and cascading hazards and systemic risks are not explicitly mentioned. Several severe environmental pollution incidences have happened recently, indicating the need to strengthen enforcement. Policies with a strong focus on governance are the National Water Resources Policy, National Policy on Climate Change, National Policy on Biological Diversity, National Action Plan for Peatlands, National Policy on the Environment, and National Low Carbon Cities Masterplan, among others.

Groundwater is considered an important water supply source to supplement surface water supply in several national policies and strategic plans. These include the National Policy on the Environment (2002), National Water Resources Policy (2012), National Agrofood Policy (2011-2020), Green Technology Master Plan

Policy	CCM	Climate Change Impacts and Adaptation											
		CM	DR	Sw	Gw	FS	Ag	CP	FB	If	Hw	SE	Gv
National Policy on Climate Change (KASA, 2009)	10	2	6	4	4	4	5	3	7	6	4	4	15
National Water Resources Policy (KASA, 2012)	-	-	16	2	2	-	-	-	-	1	-	4	23
National Green Technology Policy (KASA, 2009)	1	-	-	-	-	-	-	-	-	2	-	1	1
National Action Plan for Peatlands (KeTSA, 2011)	3	-	7	1	-	-	5	-	7	-	-	1	14
National Agrofood Policy (MAFI, 2011-2020)	-	-	-	-	1	7	7	-	1	-	-	-	-
Second National Policy on Urbanization (KPKT, 2016 – 2025)	11	-	5	-	-	-	-	-	-	7	1	-	3
National Policy on Rural Development (KPLB, 2030)	1	-	1	-	-	1	6	-	6	-	-	2	-
Green Technology Master Plan (KASA, 2017 – 2030)	3	-	3	2	2	1	5	-	2	1	1	1	3
National Policy on the Environment (KASA, 2002)	4	-	2	-	1	-	1	1	4	-	1	1	14
National Renewable Energy Policy & Action Plan (KASA, 2010)	5	-	-	-	-	-	-	-	-	-	-	-	-
National Energy Efficiency Action Plan (KASA, 2015)	5	-	-	-	-	-	-	-	-	1	-	-	-
National Transport Policy (MOT, 2019 – 2030)	3	-	-	-	-	-	-	-	-	-	-	-	-
National Policy on Science, Technology & Innovation (MOSTI, 2013 – 2020)	1	-	-	1	1	1	1	-	1	1	1	-	-
National Policy on Biological Diversity (KeTSA, 2016 – 2025)	5	-	1	-	-	-	7	-	5	-	-	-	25
National Ecotourism Plan (MOTAC, 2016 – 2025)	2	-	-	-	-	-	-	1	1	1	-	-	1
National Plan of Action for Nutrition of Malaysia III (MOH, 2016 – 2025)	-	-	1	-	-	-	-	-	-	-	-	1	-
Malaysian National Environmental Health Action Plan 2013 (MOH, 2013)	-	-	-	-	-	-	-	-	-	-	8	-	4
National Policy on Solid Waste Management (KPKT, 2016)	-	-	-	-	-	-	-	-	-	-	-	-	5
National Community Policy (KPKT, 2019)	-	-	-	-	-	-	-	-	-	-	1	-	-
Shared Prosperity Vision (MEA, 2030)	2	-	-	-	-	-	-	-	-	1	-	-	-
National Cleanliness Policy (KPKT, 2019)	-	-	-	-	-	-	-	-	-	-	1	-	13
Communications and Multimedia Blueprint (KKMM, 2018 – 2025)	-	-	1	-	-	1	1	-	-	1	1	-	-
Malaysia Shipping Master Plan (MOT, 2017 – 2022)	1	-	-	-	-	-	-	-	-	-	-	-	-
National Forestry Policy (JPSM, 1978) (Revised 1992)	-	-	1	-	-	-	-	-	11	-	-	-	-
Pelan Strategik Jabatan Hutan Sarawak (Forest Department Sarawak, 2015 – 2020)	-	-	-	-	-	-	-	-	5	-	-	-	-
Sabah Forestry Policy (Sabah Forestry Department, 2018)	-	-	-	-	-	-	-	-	14	-	-	-	2
National Education Policy (MOE, 2017)	-	-	7	-	-	-	-	-	-	-	-	-	-
The National Biofuel Policy (MPIC, 2006)	1	-	-	-	-	-	-	-	-	-	-	-	-
National Physical Plan-3 (KPKT, 2016)	10	1	7	6	1	2	5	2	3	9	-	-	-
The National Physical Plan for Coastal Zone Areas (KPKT, 2012)	1	-	2	-	-	-	1	5	1	-	-	-	-
Central Forest Spine (CFS): The Master Plan for Ecological Linkages (KPKT, 2010)	-	-	-	-	-	-	-	-	10	-	-	-	-
National Policy on Science, Technology and Innovation (MOSTI, 2021 – 2030)	1	-	-	-	-	-	1	-	-	-	2	-	-
National Timber Industry Policy (MPIC, 2009 – 2020)	1	-	-	-	-	-	-	-	2	-	-	-	1
National Biotechnology Policy (MOSTI, 2005)	-	-	-	-	-	-	1	-	-	-	-	-	-
National Space Policy (MOSTI, 2030)	-	-	3	-	-	-	1	-	-	-	-	-	-
National Automotive Policy (MITI, 2020)	1	-	-	-	-	-	-	-	-	-	-	-	-
Dasar Perhutanan Malaysia (KeTSA, 2021)	1	-	2	2	-	-	-	-	41	-	-	10	8
Malaysia Smart City Framework (KPKT, 2018)	14	-	7	2	2	3	3	-	-	-	-	-	2
National Standards for Drinking Water Quality (MOH, 2000) (Revised 2004)	-	-	-	4	-	-	-	-	-	-	4	-	6
Public Sector Open Data Initiative (MAMPU, 2014)	1	-	-	-	-	1	2	-	1	-	-	-	-
Low Carbon Cities Framework (KASA, 2011)	35	-	2	1	-	-	-	-	3	29	-	-	-
National Low Carbon Cities Masterplan (KASA, 2021)	25	-	-	-	-	-	1	-	1	4	-	-	19
National Security Policy (MKN, 2021-2025)	-	-	5	3	-	1	1	-	-	-	4	1	-

Number of Measures (Strategies, Actions and Initiatives) on climate change in National Policies:
CCM: Climate Change Mitigation; CM: Climate Modelling (Climate Factors/Projection); DR: Disaster Risk Reduction (Impact Drivers); Sw: Surface Water Security; Gw: Groundwater Security; FS: Food Security; Ag: Agriculture; CP: Coastal Protection; FB: Forests & Biodiversity; If: Infrastructure; Hw: Health & Wellbeing; SE: Socio-economic; and Gv: Governance

Very High Coverage, > 20 measures
High Coverage, 10-20 measures
Medium Coverage, 5-10 measures
Low Coverage, < 5 measures
- No Coverage

Figure 3 An overview of coverage on climate actions in 43 national policies of Malaysia

(2017-2030) and the 11th Malaysia Plan. The National Policy on the Environment (2002) states developing a systematic and comprehensive inventory of existing groundwater resources to support a long-term national plan for water management and protection. The National Water Resources Policy articulates strategies on adopting plans to protect surface and groundwater connectivity, establishing mechanisms to safeguard the hydrological and hydrogeological functions connecting surface and groundwater, and integrating qualitative and quantitative aspects on flow conditions to ensure that groundwater abstraction is within sustainable yield. The National Agrofood Policy also mentions that groundwater will be utilised for agriculture use to ensure sustainable water consumption. The Green Technology Master Plan notes that the coverage of water supply to rural areas of Kelantan, Sabah and Sarawak is limited. Groundwater is considered a major resource for providing water supply to remote areas and regions with poorly connected end-users.

The National Green Technology Policy (NGTP) was the impetus for an initiative on low carbon cities. The National Low Carbon Cities Master Plan (NLCCMP) documents the direction and goals for the transition towards low carbon cities in Malaysia. It describes what it takes for a city to declare itself a low-carbon city and lays out the federal, state, and local governments steps to advance the low-carbon agenda. The City Hall of Kuala Lumpur (DBKL), Ampang Jaya City Council (MPAJ) and Petaling Jaya City Council (MBPJ) are currently leading in this initiative. Cities are not explicitly mentioned in the National Policy on Climate Change but it has been noted that the country has a national programme on climate change mitigation in cities. However, a similar programme is absent for building climate and disaster resilience in cities. The Malaysian Government participated in the United Nations International Strategy for Disaster Reduction (UNISDR) Making Cities Resilient Campaign in 2011, introducing Kuala Lumpur, Melaka and Putrajaya as model cities. Moving on from this campaign, DBKL is now operating a Multi-hazard Platform (MHP), which is a

city-level forecasting system for weather, geophysical and atmospheric hazards, developed by a UK-Malaysia consortium supported by the Newton Ungku Omar Fund. The MHP is currently functioning with technical support from the Malaysian Meteorological Department (MET Malaysia), Universiti Kebangsaan Malaysia and other parties. The initiative has great potential to be transformed into a nationwide programme, to promote climate resilient low carbon cities in the country.

5.1.3 Proposals

An overall framework for climate change adaptation is required in the country, which could be developed in conjunction with local stakeholder inputs and scientists and practitioners from multiple disciplines and sectors. A step-wise adaptation approach could be implemented at the river basin and local scales, with IWRM as a vehicle to promote climate change adaptation. Measures need to be identified to strengthen disaster risk governance, upgrade disaster related decision-making systems, build capacity, promote strategic investment in climate proofing infrastructure and assets, mainstreaming groundwater usage and promoting nature-based solutions, among others. In this regard, a National Policy on Disaster Risk Reduction that gives priority to preparing the country for the impacts 1.5°C global warming is critical. The National Policy should also take into account the impacts associated with all the probable range of global warming.

Whole lifecycle monitoring of pollutants is needed for more efficient management of industrial and municipal waste. The existing master plan for wastewater treatment plants and policies could be further improved for more sustainable water resource management. Proper and thorough clean-up of contaminated sites such as ex-mining areas and ageing landfill would be necessary to avert adverse effects in the future. The identification of emerging non-point sources of soil pollution such as agricultural land is also important. This is to prevent pollutant mobilisation by floodwaters due to climate extremes, contaminating surface water resources and subsequently groundwater aquifers.

In addition to delineating climate resilient groundwater resources, a key solution to handle emerging issues is transitioning groundwater management to groundwater governance, which stresses the participation of multilevel stakeholders. Water resources governance involves coordination of a range of stakeholders including political, social, economic, environmental and institutional actors in managing surface water resources and aquifers for providing water supply and transboundary related issues. This approach involves scientists, policy makers, industry players and end-users by considering each of their concerns on the freshwater supply. It contributes in alleviating the burden of responsibilities the government carries to ensure the sustainability of groundwater resources.

Resilience has become a key challenge for cities, especially in the face of climate change. Resilient cities have the capacity to adapt and transform in the face of adversity. They can plan for the expected and the unexpected by involving and preparing communities to effectively prevent and respond to current and emerging hazards. The National Low Carbon Cities Master Plan (NLCCMP) should be reviewed to include the component of climate and disaster resilience. Furthermore, there is need for enhanced understanding on the subsurface condition of cities and emerging risks as development proceeds in a changing climate. Resilience building that draws on both surface and subsurface information will ensure that the efforts undertaken by cities to reduce their carbon footprint is complemented, by reducing their exposure to disaster risks due to climate extremes.

5.2 Comparative Analysis (Scope 2)

The second scope involves content analysis of documents from multi-lateral regional agencies. The purpose is to obtain an insight on climate change adaptation linkages to IWRM, water management strategies and technology in the Association of Southeast Asian Nations (ASEAN). The methodological framework of the content analysis involved several steps. Approximately 27 relevant sources, 53 potential documents and 82 emerging keywords were used to conduct the analysis. The final analysis relied primarily on documents from ASEAN to get a representative snapshot of the region (**Table 3**).

Table 3 List of Documents Used for Content Analysis Process

Sources	Documents	Year
The United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP)	Ready for the Dry Years: Building resilience to drought in South-East Asia	2020
	The Disaster Riskscape across South-East Asia	2019
	Southeast Asia Subregion Challenges and Priorities for SDG Implementation 2017	2017
	Growing together – Economic integration for an inclusive and sustainable Asia-Pacific century	2012
	Climate Change Adaptation for Water Management in a Green Economy	2012
The Asian Development Bank (ADB)	ADB's Climate Change and Disaster Risk Management Program	2019
	Asian Development Outlook 2019	2019
	Asian Development Outlook 2017 Update; Sustaining development through public–private partnership	2017
	A Region at Risk: The Human Dimensions of Climate Change in Asia and the Pacific	2017
	CLIMATE CHANGE OPERATIONAL FRAMEWORK 2017–2030 Enhanced Actions for Low Greenhouse Gas Emissions and Climate-Resilient Development	2017
	Southeast Asia and the Economics of Global Climate Stabilisation	2015
	Climate Change in Southeast Asia: Focused Actions on the Frontlines of Climate Change	2015
	Urban Water Supply and Sanitation in Southeast Asia: A Guide to Good Practice	2014
	Investing in resilience: ensuring a disaster-resistant future	2013
	Addressing Climate Change and Migration in Asia and the Pacific	2012
	The Economics of Climate Change in Southeast Asia: A Regional Review	2009
The Association of Southeast Asian Nations (ASEAN)	Fifth ASEAN State of the Environment Report	2017
	ASEAN Cooperation on Water Resources Management	2016
	ASEAN Socio-Cultural Community Blueprint 2025	2016
	Report of the ASEAN Regional Assessment of MDG Achievement and Post-2015 Development Priorities	2015
	Peatlands and Climate Change in Southeast Asia	2013
	ASEAN Strategic Plan of Action on Water Resources Management	2005

5.2.1 Climate Change and the Water Sector in ASEAN

There are strong linkages between climate change adaptation (CCA) and integrated water resource management (IWRM) in the region. The IWRM component includes demand management, aquifers transboundary management, enhanced watershed services, upholding natural capital, promoting green growth and implementing economic instruments among others. Non-structural adaptation initiatives and policies link CCA and IWRM to disaster risk reduction measures such as awareness building, training, capacity building and early warning and governance aspects. Integrating climate change into agriculture, fisheries, and livestock planning and addressing drought management through water management is an effective approach in ASEAN. In this approach, the use of IWRM as an integration framework involves engagement with multiple stakeholders, including local communities and multisector custodian agencies, drawing on information related to climate variability and climate change. Thailand, Singapore and Malaysia are found to implement adaptation strategies with higher frequencies while Singapore, Malaysia, the Philippines and Thailand have higher levels of implementing IWRM practices. However, the Philippines, Viet Nam, Singapore, Thailand and Indonesia are found to implement most adaptation options related to IWRM. In terms of implementing water resource management strategies for strengthening disaster risk reduction, Singapore, Viet Nam, Malaysia, Indonesia, Philippines and Thailand are among the top countries in the region.

The nature of collaboration and inclusion of sectors extends beyond the traditional water decision making sphere of IWRM. Policies need to take into account climate variability and the long-term impacts of climate change. There is a need for scientific models of future climate patterns. Furthermore, considerations should be given to the effect of increased frequency and intensity of rainfall on current flood management plans, resilience and coping capacity. It is necessary to review existing risks and make efforts to reduce disaster risks, vulnerability and the level of exposure to flooding. A river basin approach would facilitate the achievement of optimal operational policies. Communities should be empowered to develop their own systems and management strategies, such as hazard maps, evacuation plans and improved water retention methods suitable to the geographical and cultural context, as part of the overall water management scheme. This calls for the development of country-specific plans based on national risk profiles.

Significant policy and investment changes are required for climate change adaptation for the future of sustainable water in the region. It has been recommended that the National Adaptation Programme for Action (NAPA) for ASEAN Member States strongly emphasise short-term actions and identify long-term strategies. New infrastructure should incorporate climate change adaptation into the design and existing ones should be retrofitted to be climate resilient to climate impacts. Floodplains need to be recognised as an important part of natural flood management and these ecosystems should be carefully managed (**Box 1**). Existing flood management and city development guidelines should be reviewed, and updated to reflect the changing risks associated with climate variability and anthropogenic pressure. Near term development and urbanisation should take into consideration flood management. Evaluation of dam construction and design should also consider the impacts of climate change, to ensure that the structure will be suitable under future conditions and avoid maladaptation. The involvement of decision makers from all sectors and levels in adaptation planning and implementation is important to ensure the success of IWRM. The society must adapt its water infrastructure and services to be more resilient to the changing climate and to reduce vulnerability to water hazards. Other aspects include selecting more water-efficient crop varieties, reducing water loss, improving water use efficiency and water recycling, as well as improving the quality of water released into the natural system, with minimal residuals from fertilisers and pesticides.

Several priorities related to groundwater management have been identified in the region. These include community-run groundwater allocation programmes and seasonal groundwater storage by enhancing infiltration into the aquifers during high flow periods to increase the availability of groundwater during the

growing season. Rainwater harvesting and groundwater harvesting such as Managed Aquifer Recharge Storage (MARS) systems are also being looked into as a priority action. The importance of maintaining forests and vegetation to absorb precipitation, recharge groundwater and stabilise soil has been emphasised. The planning of a new reservoir in the Ninh Thuan Province in Viet Nam includes a holistic water system analysis across the entire Dinh River Basin, to assess both surface and groundwater resources for current and future demand. In Cambodia, Open Data Cube tools are being used with support from Geoscience Australia, to facilitate integrated management and interrogation of geospatial and other databases.

BOX 1: CITIES AND CLIMATE CHANGE

A: Before and after aerial view of the Bishan-Ang Mo Kio Park, Singapore.

B: Empty spaces in cities are ideal for conversion to urban farming.

Cities offer the best opportunity for addressing disaster and climate risks whilst promoting low carbon development. Initiatives that support IWRM include improving drainage systems and urban farming.

Improving the drainage system in cities: The Bishan-Ang Mo Kio Park is a welcoming green oasis in the heart of central Singapore. It was once bounded by a three-kilometre concrete canal that ran along its southern border. The canal frequently flooded, causing flooding on surrounding roadways. Singapore began removing the concrete from the canal in 2009, transforming it into a meandering river (See A). The end effect was not only more aesthetically pleasing, but it also delivered better drainage and water quality. The development is also supporting the local wildlife and conserving biodiversity. This endeavour exemplifies a growing trend in cities worldwide: the utilization of natural features to manage water flow and mitigate the risk of flooding. From a wide perspective, it demonstrates how cities are adapting to the reality of a rapidly changing environment.

Urban farming: Urban agriculture, also known as urban farming, represents agricultural activities within an urban setting (See B). It delivers multiple benefits including building community resilience and contributing to food security. Urban farming integrates vertical farming with controlled environment agriculture and soilless farming techniques e.g., hydroponics, aquaponics, and aeroponics. Urban farming helps to address climate change at the local level and provides urban populations with the many environmental, social, health and economic benefits. Increasing biologically productive green space will also help to relieve the urban heat island effect, serve as a water management strategy, and enhance urban food security. In addition, urban agriculture will help to mitigate further climate change by reducing transportation needs and transforming the current agricultural practices that contribute to global warming.

Source: Othman et al., 2017; Mohd Salleh et al., 2020.

5.2.2 Proposals

Malaysia appears to have the second highest level of implementing IWRM practices in the region, after Singapore. In terms of implementing water resource management strategies for strengthening disaster risk reduction, Malaysia is among the top three countries in ASEAN, after Singapore and Viet Nam. However, it appears that Malaysia is less advanced in implementing climate change adaptation strategies related to IWRM. The Philippines, Viet Nam, Singapore, Thailand and Indonesia are relatively more advanced in this respect. The way forward for the country is to improve communication on existing IWRM practices including strategies and technology, and its linkages to disaster risk reduction. At the same time, there is an opportunity to take proactive actions to strengthen climate change adaptation through IWRM by promoting a river basin approach to facilitate achievement of optimal implementation. In this regard, Malaysia could strengthen its participation at the various regional platforms of ASEAN and engage in more technical cooperation. Ministries and agencies that serve as National Focal Points have a critical role in this context. For example, experts from universities and the private sector could be included as part of the delegation for relevant sessions, to showcase the Malaysian technology and sharing of experience.

5.3 River Basin Case Studies (Scope 3)

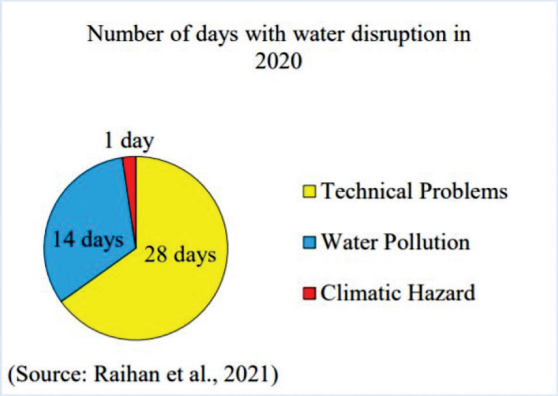
The third scope focuses on river basins to take into account the nature of climate change adaptation, which is context and area specific. In order to leverage on the water sector as a potential new economic driver of growth, a river basin approach is required for site-specific prioritisation of climate risks. The Selangor River Basin is the primary case study to identify the opportunities and challenges with focus on vulnerable populations, resources, innovative approaches, technology and knowledge gaps. The Selangor River Basin was selected because of its important role in supplying water to the Klang Valley, which is the most developed region and important income generator for the nation. Water disruption from the Selangor River is estimated to result in significant losses (**Box 2**). A cursory review of groundwater was also conducted on the Muda River Basin, given the importance of the area to ensure food security.

5.3.1 Selangor River Basin

Selangor River Basin is a major supplier of water resources in the Klang Valley, supporting more than 4 million people in the area of Selangor, Kuala Lumpur and Putrajaya. Water catchment forests surround the major dams located in the basin (**Figure 4**). Human settlements and industrial areas are scattered throughout the basin, both in the upstream and mid-stream areas such as in Rawang, Kundang, Bukit Beruntung, Batang Kali, Serendah and some parts of Hulu Selangor, as well as in downstream Kuala Selangor. Climate change is expected to bring more challenges to the basin. Major concerns include sea level rise and extreme weather events resulting in low river flow and water stress incidents as well as higher magnitude and more frequent floods, coastal erosion, soil erosion and landslides, among others (NAHRIM, 2021). Climate change is expected to influence not only the weather-related events, but also the quality of water and land resources (Miller et al., 2017). Under the impact of climate change, areas that are already susceptible to flooding are expected to experience more frequent and higher magnitude of floods (IPCC, 2021). Areas in floodplains that have not experienced floods will face such events as flooded areas expand due to more intense rainfall.

BOX 2: COST OF WATER DISRUPTION FROM THE SELANGOR RIVER

Water supply disruption is unsettling to communities and businesses. Based on the collation of reports in the media, the Klang Valley experienced a total of 465 events of water supply disruptions throughout the period of 2005-2020 (Raihan et al., 2021). The causes were due to technical problems, water pollution and small-scale climatic hazard events. The climatic hazards comprise rainfall-induced landslides, floods and dry spell. In 2020, the Klang Valley experienced a total of 43 days of water disruption (top right). The areas that experienced the disruption covered a total of 673 sq. km comprising eight districts. These include parts of Kuala Lumpur and the districts of Petaling, Klang, Hulu Langat, Gombak Kuala Langat, Kuala Selangor and Sepang.

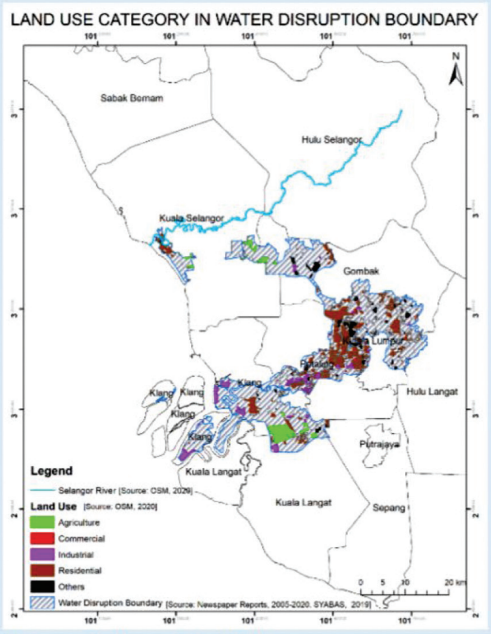


(Source: Raihan et al., 2021)

A recent investigation to assess the economic impacts of water supply disruption from Selangor River included evaluating property value at risk due to water disruption and estimating business loss. The property value at risk due to water disruption was based on the methodology from Gawande and Jenkins-Smith (2001). The number, price, and transaction of residential, commercial, and industrial property (stock) were obtained from National Property Information Centre (NAPIC). The business loss estimation was based on a survey conducted between May and June 2021 using the purposive random sampling method (Selelo et al. 2007). The survey involved 117 respondents from small and medium enterprises (SMEs) representing the manufacturing, construction and services sector.

The findings show that the total property value at risk due to water disruption in the Klang Valley is estimated at approximately RM 459,041 million (Raihan et al., 2021). This covers commercial property valued at RM 532 million, residential property valued at RM 414,328 million and industrial property valued RM 44,181 million (Raihan et al., 2021). Agriculture land was not included in the study as it does not receive treated water supply.

About 46% of the respondents involved in the survey reported business loss due to water disruption. In a scenario where all the SMEs were affected by the water disruption in 2020, the total business loss due to water disruption is estimated at about RM 4,464 million (Raihan et al., 2021). In comparison, if only 46% of the SMEs are affected, the loss is estimated at about RM 2,053 million in 2020 alone (Raihan et al., 2021). A major limitation of the survey is the small sample size and low response due to COVID pandemic. However, the investigation does provide some insights on the importance of ensuring undisrupted water supply from the Selangor River.



(Source: Raihan et al., 2021)

References:

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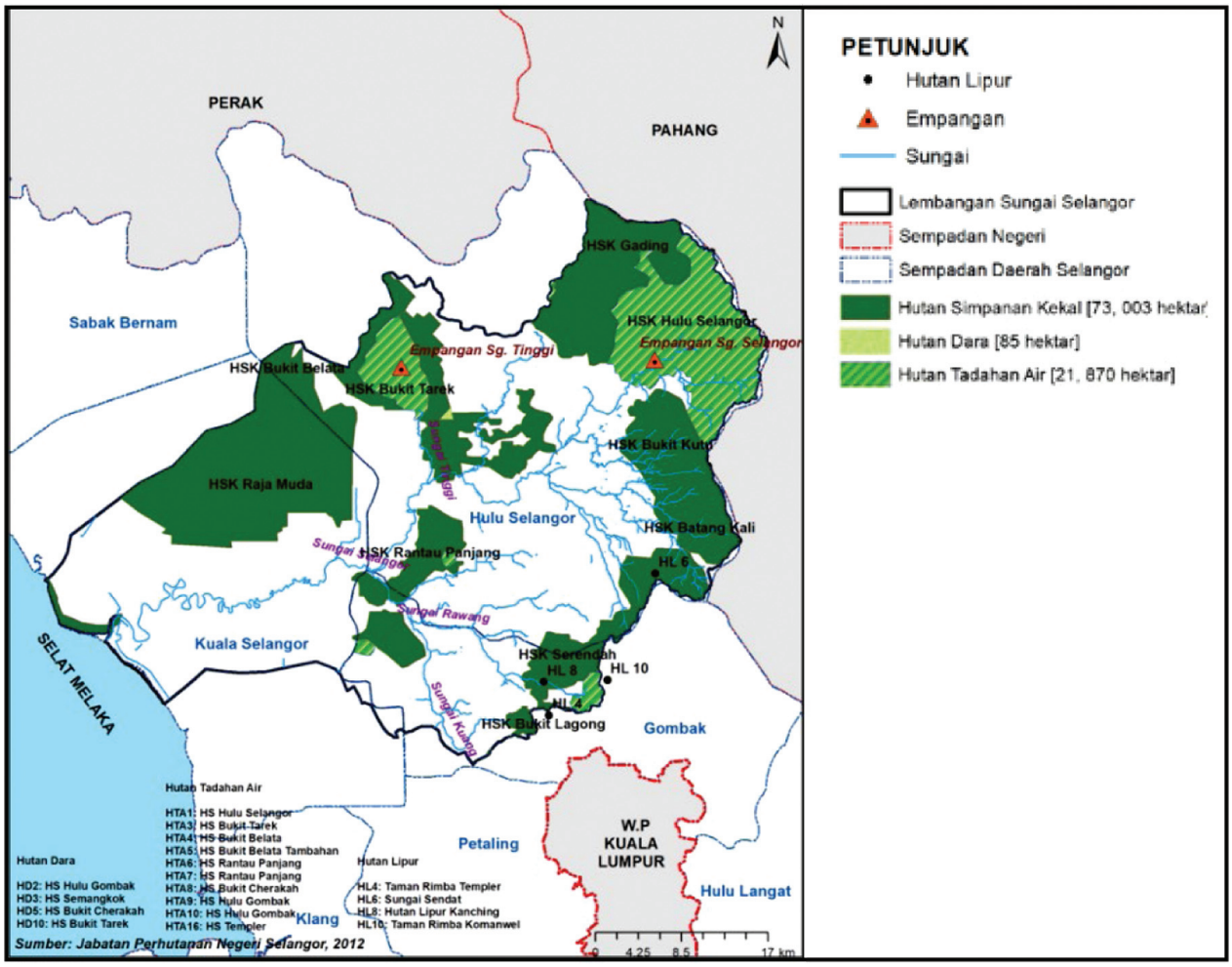


Figure 4 The Location of Permanent Forest Reserves, Virgin Forests and Catchment Forests in the Selangor River Basin. (*Source*: JPBD, 2017)

5.3.1.1 Coastal Susceptibility

Climate change also poses a threat to humans and natural ecosystems in the coastal zone of Kuala Selangor. This is a major concern as the low-lying area of Kuala Selangor is a significant "rice bowl" for the country. Projected sea level rise will increase the susceptibility of low-lying areas to coastal inundation and compromise existing land use. In the absence of adaptation measures, sea level rise of 0.5 m is projected to inundate an area of approximately 7,641.72 ha and this is expected to increase to 11,795.13 ha if sea level rise proceeds to 1.0 m by 2100 (Jamaluddin et al., 2018). About 90% of the exposed components are agricultural and forest areas, while the rest comprise built assets from the transportation, residential, infrastructure, business, public institutions and industry sectors (**Figure 5**). The projected economic losses have not been assessed. Sea level rise is also expected to accelerate saltwater intrusion into the coastal groundwater aquifers in Kuala Selangor (Jamaluddin et al., 2018).

Coastal reservoirs are extensively promoted as a sustainable approach to solve water scarcity due to climate variability and rapid population growth (Yang, 2018; Teo et al., 2019). However, the development of such reservoirs requires careful consideration as the structure requires significant investment and would have to be defended from coastal hazards as sea level rises (Sivakumar et al., 2020). Furthermore, the implementation of coastal reservoirs will not resolve the issue of water pollution, which is expected to become increasingly challenging due to climate extremes. Investments would still be required for the installation of real-time water quality monitoring stations and wetland pre-treatment to improve river water quality.

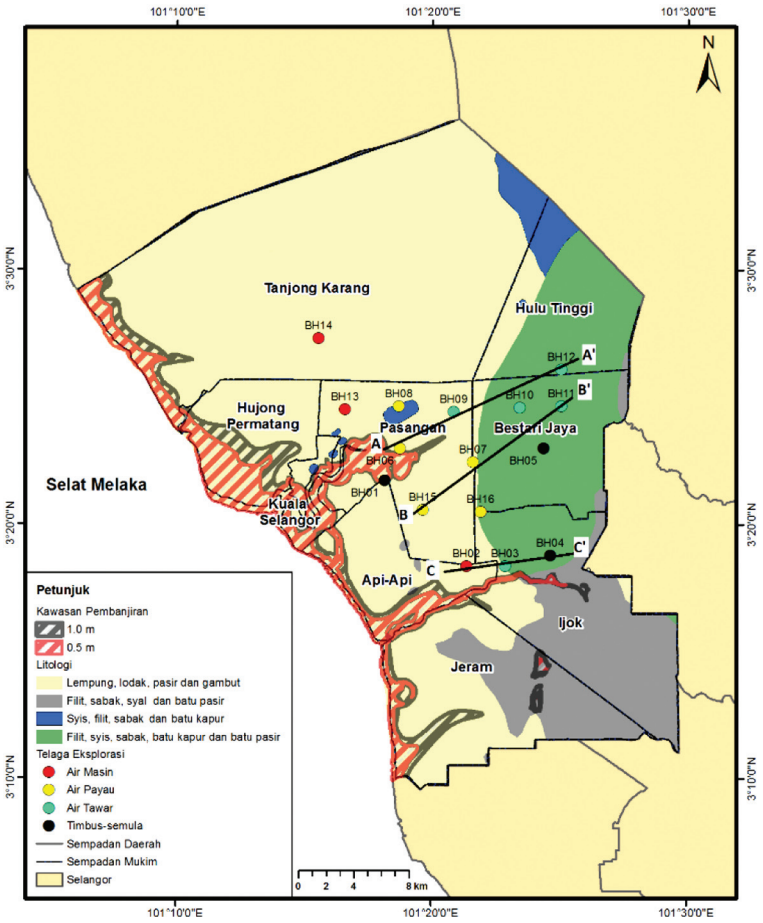


Figure 5 The Extent of Inundation Projected with 0.5 M and 1.0 M Rise of Sea-Level in Kuala Selangor, without Any Adaptation Measures (*Source*: Jamaluddin et al., 2018)

5.3.1.2 Surface Water and Legacy Pollution

In recent times, there are high level of concern regarding occurrences as well as potential risks of emerging and legacy pollutants in the environment due to limited monitoring and regulations. Emerging pollutants comprise chemicals and compounds recently identified as dangerous and could have adverse effects on humans and the environment. These may originate from natural sources or produced synthetically including personal care products (PCPs), industrial based chemicals, wood preservative, and pharmaceuticals. Studies conducted in Malaysia have shown the presence accumulation of these pollutants in rivers, marine environment, as well as their presence in tap water in different parts of the countries (Razak et al., 2021; Praveena et al., 2021; Ismail et al., 2020; Wee et al., 2020; Aris et al., 2014). Human activities, such as land use development, may contribute to the presence of emerging pollutants in rivers (Talib et al., 2020).

The issue is further compounded by legacy pollution that may be aggravated under climate change, as more frequent floods will enhance the mobilisation of persistent pollutants stored in floodplain sediments. Contaminated sediments from industrial areas could be mobilised to uncontaminated river sediments in other areas through the increasing frequency of flooding that turns the floodplain from being the sink of pollutants to the source of pollutants (**Figure 6**). This would deteriorate the quality of land resources in wider areas and pose a long-term risk to the water resources through infiltration (Ponting et al., 2021). In addition to addressing the immediate impacts of pollution on water resources, the long-term and more widespread deterioration of land resources under the impacts of climate change is important, due to the potentially insidious impacts on the ecosystem and its services that are key to societal well-being.

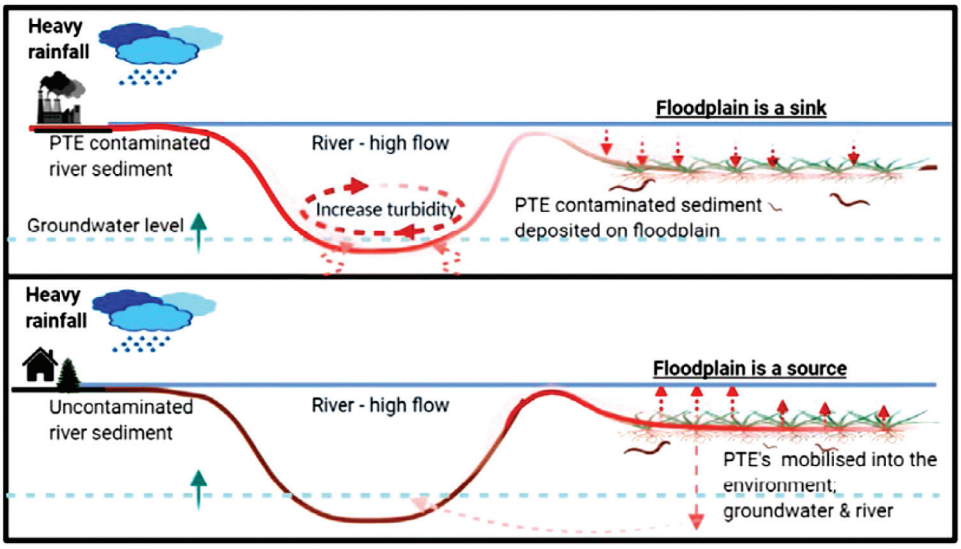


Figure 6 Increased Flooding Occurrence that will Impact the Mobility of Potentially Toxic Elements in Floodplain Soil, Switching from Being Sinks to Becoming Sources of Legacy Pollution (*Source*: Ponting et al., 2021)

In general, the Selangor River shows a strong gradient of heavy metal concentrations moving from upstream to downstream (Daniel and Kawasaki, 2016). In the Rawang sub-basin of the Selangor River (where many heavy industries are located), river water samples are found to be more polluted than other parts of the river with the average concentration of As, Fe, and Mn exceeding the limit of the National Standard Drinking Water Quality (NSDWQ) and standard proposed by the Ministry of Health (Daniel and Kawasaki, 2016; Othman et al., 2018). Organic pollutants are also quite prominent in the Selangor River. Organochlorine plasticides and plasticisers (OCPs, PAEs and BPA) are found along the Selangor River with the BPA levels exceeding the limit in a majority of the samples (Santhi and Mustafa, 2012). The concentrations of most plasticisers are almost 2 times higher during the dry season at downstream stations. Nickel (Ni) and zinc (Zn) are found discharged from sewage and/or industrial effluents while lead (Pb) has been traced to mining sites (Sakai et al., 2017).

An investigation of the ex-mining area in Bestari Jaya for water quality and heavy metals in soil found that most of the physio-chemical parameters and metals concentration exceeds the permissible limits set by the Malaysian interim national water quality standards (Ashraf et al., 2011). Sediment loading due to soil erosion from development activities and sand mining are also contributing towards the deterioration of river water quality in Selangor. It has been demonstrated that the sediment pattern upstream of the Selangor River Basin is mostly influenced by rainfall and the climate cycle during the dry period, whereas the downstream of the basin is impacted by land use change (Nurhidayu et al., 2015).

In addition to industrial areas, municipal solid waste landfills are also a source of persistent pollutants that could pose both immediate and long-term risks to the ecosystem from the start of the operation to well after their closure. Although sanitary landfills are equipped with modern and environment-friendly systems with leachate treatment facility are now preferred, a majority of the older landfills are non-sanitary or open dumps. A total of 7 registered landfills located in the Selangor River Basin, of which three are active (**Figure 7**). These are Bukit Tagar, Sungai Sabai and Bukit Beruntung. Heavy rainfall events could trigger the failure of engineered and non-engineered landfills, and these have been previously reported (Yahaya et al., 2016).

It is possible that salinisation and enhanced erosion may cause a significant release of metals from the landfills and their surrounding sedimentary systems into adjacent ecosystems, and such contamination may persist

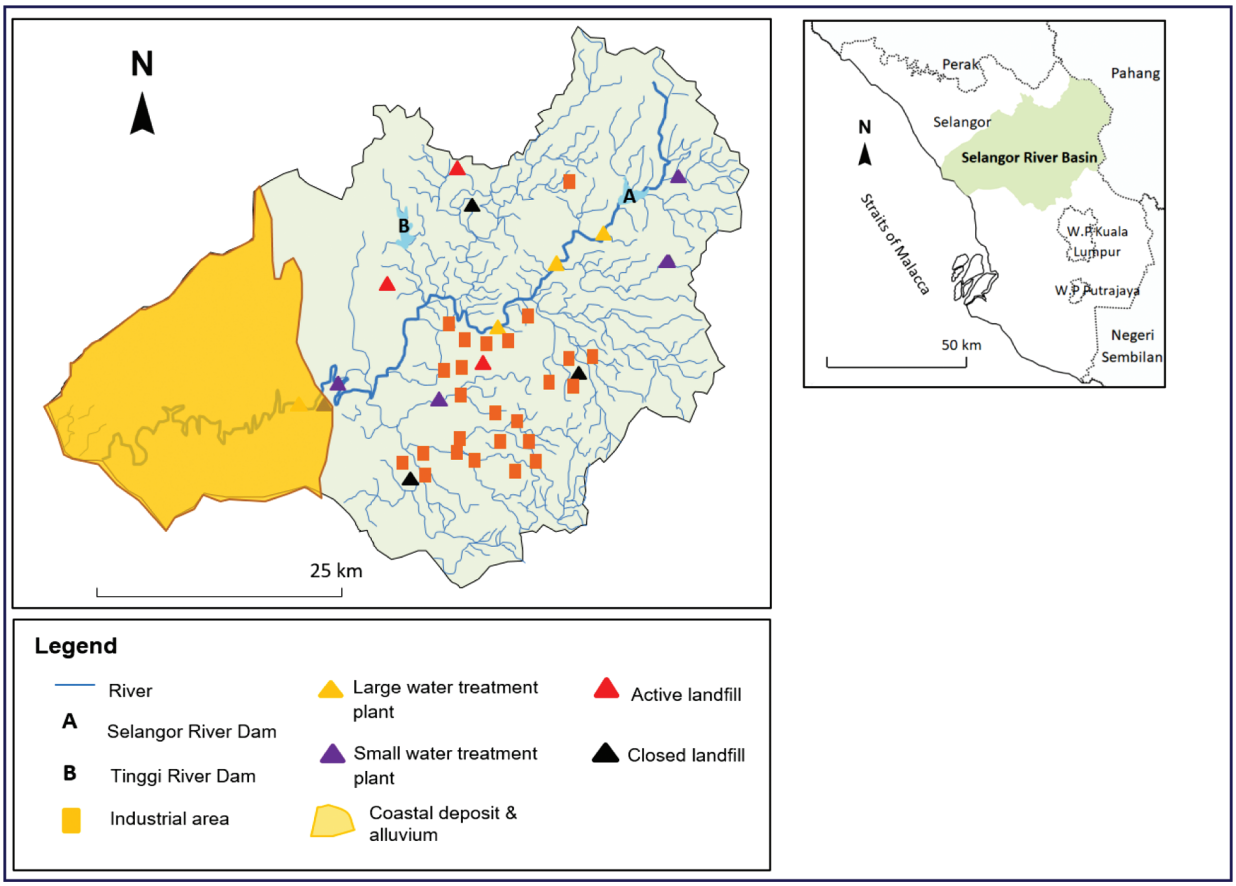


Figure 7 The Location of Water Treatment Plants, Active and Closed Landfills and Industrial Areas in the Selangor River Basin. The Filled-Out Area on the West Side of the Map Indicates the Extent of Coastal Sediment and Alluvium (*Source*: Yahaya, 2021)

for decades (Njue et al., 2012). It has been reported that As, Se and Pb are elevated in the sediment layers and aquatic organisms in the Selangor River, which could well bring threats to the biota and humans as they travel into the food web (Idris et al., 2017). In studies on human subjects residing in the Selangor River basin, although maternal blood levels of arsenic (0.82±0.61 µg/dL), cadmium (0.15±0.2 µg/dL) and lead (2.6±2.1 µg/dL) were found to be not significantly high compared to their acute toxicity levels, continuous exposure could have attributable risks of chronic toxicity (Ishii et al., 2007). Water quality modelling for emerging pollution on water and soil resources due to climate change and its implication on shifting exposure levels to humans must be further investigated. As a way forward, it is also worth to conduct more studies on the impact of climate change and pollution on the biological aspect of the river. River biota are of key importance to the health of river and ecosystem and could provide a more comprehensive perspective on water degradation under the impact of climate change (Arman et al., 2019).

5.3.1.3 Groundwater Resources

Groundwater is relatively well investigated in Selangor compared to other states in the country (Kura et al., 2018). The investigation ranges from exploration and determination of potential groundwater zones to tracer studies on contaminants. A key factor hampering the development of groundwater is the lack of adequate information to assess the reliable supply or yield that can be obtained. The basis and approach for assessing reliable supply from groundwater differ significantly from that used for surface water resources. Therefore, this creates uncertainty and a lack of confidence in the yield estimates of groundwater. The approach for surface water resources is far more stringent based on droughts with a return period of once in fifty years

and substantial related hydrological data. This shows that the yield estimates for surface water resources are more robust. Furthermore, the uncertainty in groundwater yields is reflected clearly in recent groundwater studies in conjunction with surface water and storage facilities. These studies indicate potentially very high yields but recommend the development of a scheme with far lower capacities (LUAS, 2015a; Abu Hassan et al., 2017).

A key constraint to the development of groundwater resources in previous approaches is the isolation from surface water resources. In reality, both sources are interlinked and therefore the development of a groundwater resource that is linked with surface water resources can adversely affect surface water flow regimes if this is not taken into account appropriately. The use of surface water has also been constrained by the lack of storage that can be made available to tap excess water during wet spells. Although the existing Sg. Tinggi and Sg. Selangor dams have been developed to provide storage to improve yields within the basin at Bestari Jaya in particular, additional storage would further enhance the yield. The availability of potable water within the Sg. Selangor basin in an average year is well in excess of that during dry spells or droughts. This excess water generally returns to the sea and remains unutilised for the most part due to lack of storage to tap and store this excess water. Since 2019, excess water is captured using the Hybrid Off-River Augmentation System (HORAS). The principle behind such an approach is that excess water available during wet weather or spells can be diverted into a storage pond, which can also draw on groundwater in the future. The pond therefore obtains water from both sources; groundwater and surface water (LUAS, 2015b).

The maximum reliable capacity of water resources available within the basin remains unknown and established since the groundwater potential has not been firmly established. There is a plan for groundwater resources to be investigated and exploited with appropriate monitoring in place (LUAS, 2014). The utilisation of groundwater as an alternative water resource in Selangor and the surrounding Federal Territory is relatively limited for domestic purposes. This is attributed to the fact that there have been limited detailed investigations in the past to determine its potential. The hydrogeological maps for Selangor as a whole have been available for a long time and it has been recognised that groundwater occurs in both alluvial and hard rock aquifers. The impact of climate change on these aquifers as well as their resilience during extreme dry periods need to be determined. The impetus should come from the State Government of Selangor and Lembaga Urus Air Selangor (LUAS), with support from the Department of Mineral and Geoscience Malaysia (JMG).

5.3.2 Muda River Basin

The Muda River and its tributaries play an important role in supplying water to the states of Kedah and Penang. The Muda and Pedu Dams were initially built in 1969, followed by the Ahning Dam in 1989 and Beris Dam in 2004. The Muda Dam and Pedu Dams are connected by the Saiong Tunnel, which is about 6.8 km in length. Two barrages have been built in the downstream area to protect the river water from saltwater intrusion. Almost 52% of the Muda River Basin comprises forest reserves, with 64.5% allocated for timber production and 32.3% as water catchment (JPS, 2019). In terms of land use, agriculture dominates 38%, followed by residential settlements (3.88%), transportation (1.35%), water bodies (1.62%) and other uses (3.54%). The Muda River Basin is the major granary area in the country. About 55% of the total irrigation in the area comes from rainfall, 36% from the Pedu-Muda reservoir and 9% from uncontrolled river flow (Tukimat et. al., 2017). The river basin comprises a total of 12 sub-basins (**Figure 8**).

Human activities pose a threat to water resources in Muda River Basin area. There are two sand mining activities, three waste disposal sites and five animal husbandry and wet markets that threaten the surface water and groundwater aquifers in the basin. With respect to climatic hazards, the basin has experienced

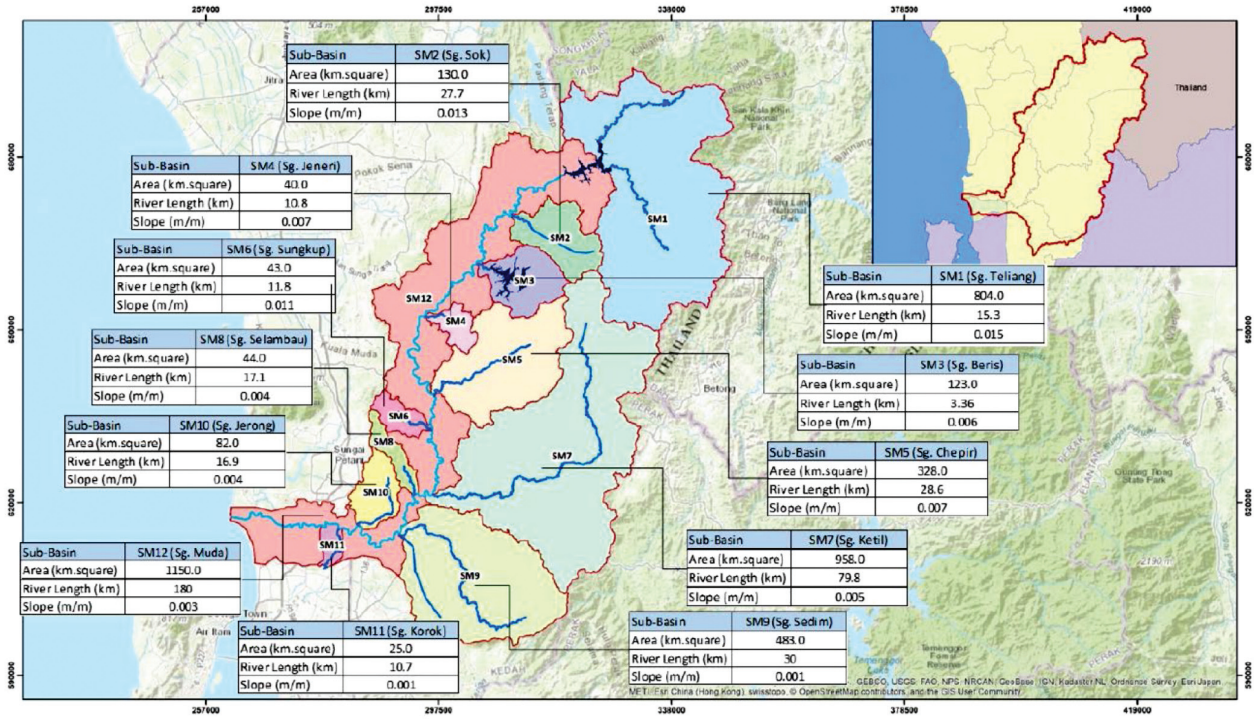


Figure 8 An Overview of Sub-basins in the Muda River Basin (*Source*: JPS, 2018)

both dry spells and floods. A severe dry spell caused the cancellation of the first-season planting in 1978, where the entire area was badly affected. In 2005, a total area of 19,185 ha (20%) was affected by the floods, with damages suffered by the paddy farmers estimated to be at 76,287 tonnes (on an average of 5.5 tonnes per hectare), with a total value of US% 13.8 million (Alam et al., 2020). Irrigation demand is expected to be much more variable in the future, and a major challenge in water resources management will be to handle the uncertainty. Expected climate change hazards include extreme events, coastal inundation and saline intrusion, among others.

Groundwater within alluvium and fractured rocks have the potential to diversify water supply sources in the Muda River Basin (**Figure 9**). There are currently nearly 50 groundwater wells in Sungkup, Ketil, Selambau, Sedim, Jerong, Korok and Muda sub-basins providing water supply for domestic, industry and agriculture purposes (JPS, 2018). Groundwater use is expected to increase by the next decade to support water supply requirements in the area. As coastal aquifers are exposed to salinisation, groundwater in fractured rocks needs to be investigated to delineate climate resilient aquifers.

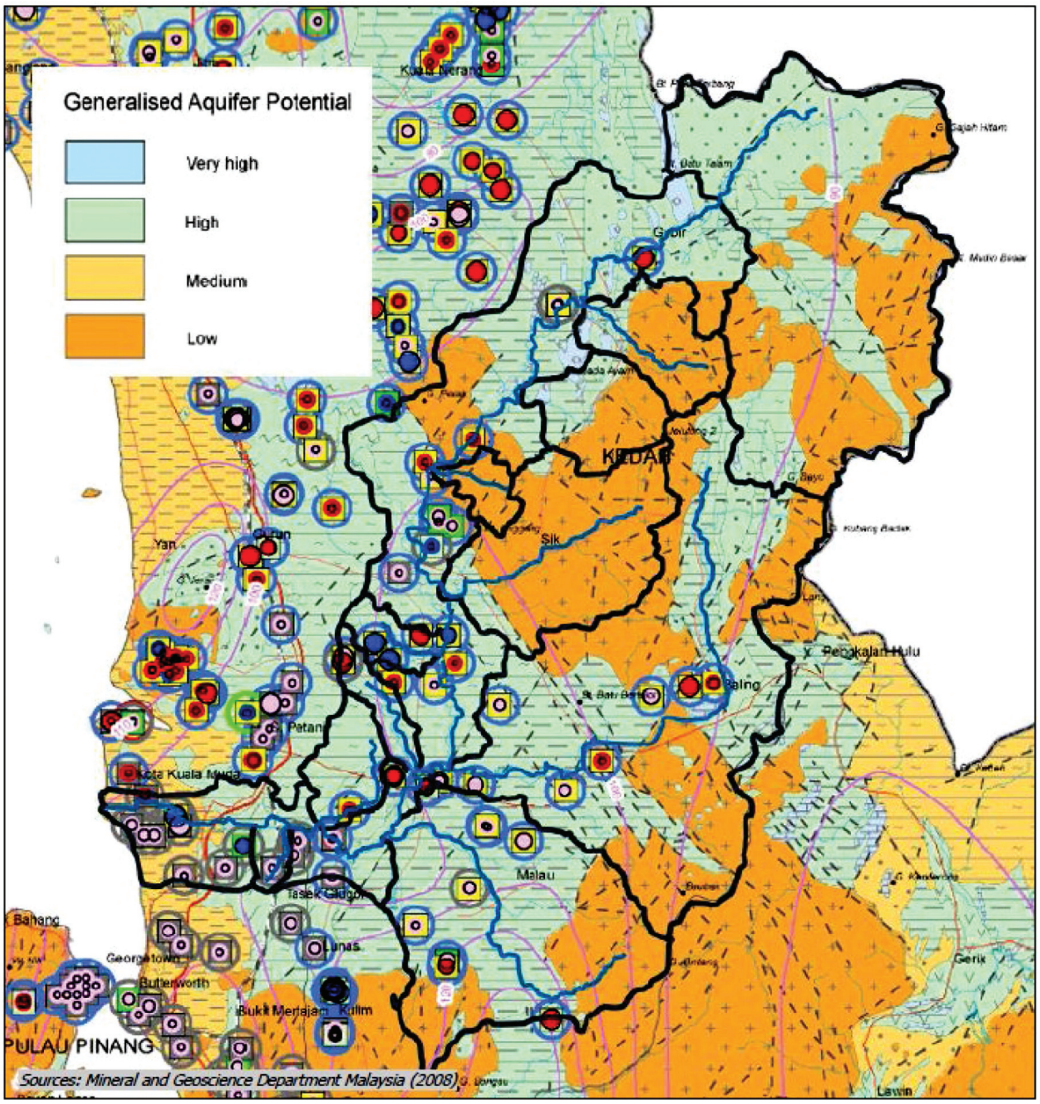


Figure 9 Groundwater Wells and Generalised Aquifer Potential in the Muda River Basin (*Source*: JMG, 2008)

5.3.3 Governance of River Basins

Governance of river basins, defined by topography spanning an entire catchment from the headlands to the coastal estuary across a range of land and water resources and multiple administrative jurisdictions, is a major challenge. Integrated Water Resources Management (IWRM) and Integrated River Basin Management (IRBM) are concepts that are integral to managing water resources. IRBM can be considered a subset of IWRM, together with associated management instruments, such as Integrated Lake Basin Management, Integrated Flood Management (IFM), Integrated Coastal Zone Management and Integrated Aquifer System Management (ASM, 2015; 2016). River basin organisations (RBOs) generally refer to any formal or informal entity that manages water resources at the basin level (GWP, 2017).

In Malaysia, the state governments are responsible for land and water resources. With respect to water resources, some states such as Sabah, Sarawak, Selangor and Kedah have established their own water resource management organisations while others rely on relevant technical departments from the federal level to manage their water resources (ASM, 2015). The National Water Resources Council (NWRC), currently known as the National Water Council (NWC) was established in 1998 at the federal level to pursue more effective water management, including the adoption of interstate water transfers. The National Water

Resources Policy (NWRP) was launched in 2012 to address the immediate problems and concerns related to water resources through 28 strategies and 69 strategic action plans that have been designed (NRE, 2012). The policy was developed to ensure that the demand for water for all user sectors is met in terms of quantity and quality for both man and nature and it will be evaluated regularly to ensure that it remains dynamic and adaptable to changing circumstances. The Ministry of Environment and Water (KASA) is currently conducting a review of the NWRP.

The establishment of RBOs have been proposed to oversee the country's various river basins to ensure those can be managed systematically in line with the IRBM practices (ASM, 2016). Existing entities such as "Lembaga Urus Air Selangor" (LUAS) and "Lembaga Sumber Air Negeri Kedah" (LSANK) are models that could be emulated.

5.3.3.1 Groundwater and Aquifers in River Basins

Water resources management by existing RBOs in the country such as LUAS and LSANK cover aspects related to catchment areas, dams and rivers, including surface and groundwater resource management. However, in many states, the traditional institutional separation of surface water from groundwater resource management has created fundamental communication barriers that hinder the understanding of surface and groundwater interactions. The absence of a policy and the legal and institutional framework related to groundwater and management of aquifers has resulted in the lack of groundwater resource development, where less than 3% of the water use in the country is from groundwater (Sharon et al., 2014; Taib, 2019).

Department of Mineral and Geoscience (JMG) is the lead agency in exploration, mapping, monitoring of groundwater resources and development activities. Other government agencies involved in the groundwater development include the Department of Irrigation and Drainage (JPS), Public Works Department (JKR), Department of Environment (JAS), Ministry of Health (MOH), Department of Agriculture (DOA) and Ministry of Rural Development (KPLB), among others. Greater coordination among the various institutions is crucial to ensure sustainable management of the groundwater resources. A comprehensive approach is required for the development of groundwater as a resource, requiring a national policy on groundwater and aquifer management.

It is proposed that the National Water Council set up a standing committee on groundwater co-led by the Ministry of Energy and Natural Resources (KeTSA) and the Ministry of Environment and Water (KASA), to oversee integrated management of groundwater, to support the transformation of the water sector by 2040. Moving forward, Malaysia needs to recognise the potential use of groundwater as a valuable water resource, which is a cost-effective climate change adaptation option. The governance of groundwater and aquifers in river basins has to be strengthened to realise the full potential of this under developed resource, more so when aquifers transcend river basins.

5.3.3.2 Disaster and Climate Risks in River Basins

The National Disaster Management Agency (NADMA) is the Secretariat for the Federal Disaster Management Committee and its organisational infrastructure for disaster management is extended from the federal level to the states and districts through a committee system (MKN, 2013; CFE-DM, 2019). The State Disaster Management and Relief Committees are responsible for managing state-level disasters while District Disaster Management and Relief Committees are responsible at their local level. The Federal Disaster Management and Relief Committee only comes into action when an event exceeds the management capacity of the local and state committees. The National Risk Register identifies floods, tsunamis, earthquakes, landslides, storms, dry spells (drought) and wildfires as the main natural hazards in the country (NADMA, 2021). The majority of

these hazards are expected to be compounded by climate change. Small disaster events that currently occur at the river basin level are managed by local authorities and district offices. These events are not accounted for as part of the cumulative loss and damage due to disaster risks. There is a need to identify disaster and climate risks at the river basin level. Since flood risk management is being expanded in river basins across the country, more effort is required to strengthen multi-hazard risk management at the river basin level.

Climate change is handled by the Ministry of Environment and Water (KASA) at the cabinet level. Coordinating ministries for key sectors include KASA, KeTSA, MOT, MITI, MAFI, MPIC, KPKT and MOH (MESTECC, 2018). Operational matters on climate change are guided and endorsed by the National Steering Committee on Climate Change (NSCCC) chaired by the Secretary General of KASA. However, the gaps in the existing governance and institutional arrangement for climate change, particularly the adaptation component are still noticeable. The top-down approach, economy-based concern, lack of physical science-based policy and integration, and limited technical and capacity building to govern climate change adaptation are among the challenges in the current governance. A national adaptation plan is critical to provide the pathway for adaptation actions and their implementation, which requires coordination of various policies and strategies concerning water resources, disaster risk and other sectors impacted by climate change. There is also a need for a framework to monitor the implementation as well as evaluate and report progress on the effectiveness of such policies and programmes across sectors at all levels in enabling adaptation.

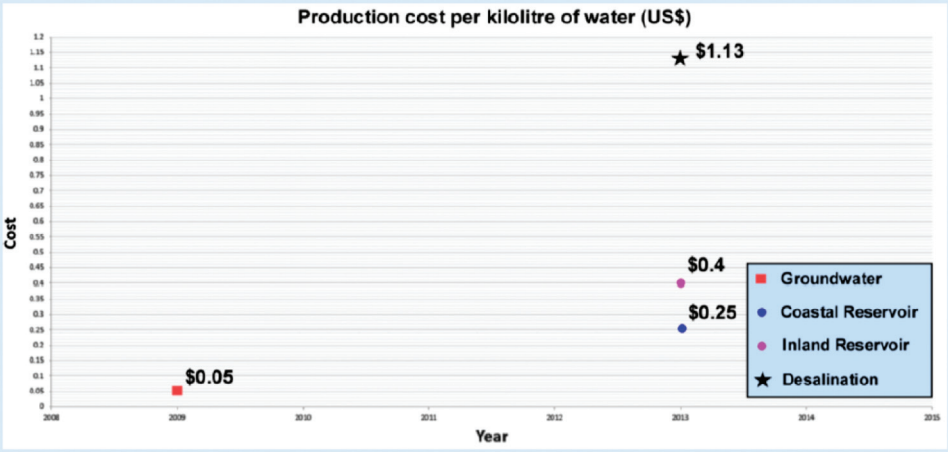
Spatial planning is a critical tool to integrate environmental and development concerns and is the way forward to address disaster and climate risks in an integrated manner (Chee et al., 2017). Elements of climate change mitigation and adaptation have been incorporated into the spatial and development planning framework through the National Physical Plan-3 (NPP-3) and National Physical Plan-4 (NPP-4). The NPP-4 strategic thrust focuses on 'Spatial Sustainability and Climate Change Resilience'. Spatial planning and development need to be coordinated from the federal down to the local level, with consistent and workable policies at all levels. These aspects have to take into account disaster and climate risks at the river basin level to be effective.

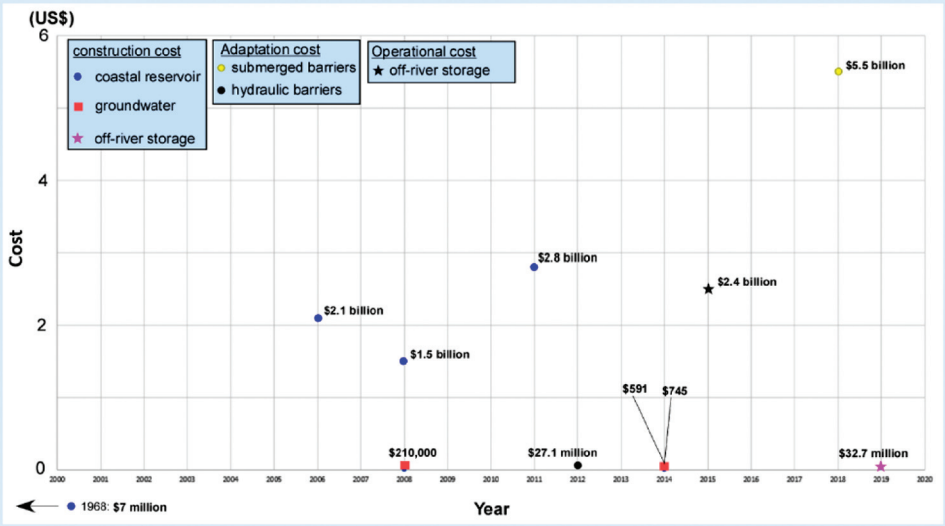
Disaster and climate resilience have been recognised as a cornerstone for sustainable and resilient development. The Twelfth Malaysia Plan (2021 to 2025) calls for integration of disaster risk reduction and climate change adaption (GoM, 2021). The management of disasters and climate risk must be based on solid policy and legislative frameworks to ensure that their tangible implementation can be applied at all levels of the government, especially when it comes to institutionalising DRR and CCA measures. The need to develop a national policy on disaster risk management and multi-level disaster resilience plans as well as a national adaptation action plan to integrate the local, structural and sectoral development plans in addressing climate change and disaster risks is critical. This is most effective at the river basin level and a framework has to be developed to outline disaster risk reduction and adaptation measures to support the Water Sector Transformation Plan (2040).

5.3.4 Proposals

The feasibility of increased groundwater use, by itself or in conjunction with surface water resources needs to be explored. A review of costs associated with groundwater supply indicates that groundwater is by far the cheapest source of water compared to other options (**Box 3**). Groundwater is especially important within the Selangor River Basin since all available surface water has been fully investigated and utilised, largely for potable water supply. Forest reserves in the Selangor and Muda Rivers Basins must be protected as groundwater recharge zone areas. The impacts of extreme rainfall patterns and saline intrusion need to be identified. In addition, investment such as Managed Aquifer Recharge Storage (MARS) system is required

BOX 3: COSTS OF GROUNDWATER SUPPLY COMPARED TO OTHER SOURCES





The cost of producing each kilolitre of water for a desalination plant is by far the highest when compared to an inland reservoir, a coastal reservoir, or groundwater resources (top chart). The cost of desalination is estimated as part of a comprehensive economic evaluation using data from Singapore, Australia, the United States of America, India, and Israel. Groundwater has the lowest production cost (USD0.05/kilolitre), making it nearly five times less expensive than water from a coastal reservoir.

The construction of coastal reservoirs requires a very high investment compared to off-river storage systems or groundwater development (bottom chart). Coastal reservoirs will require further protection from sea level rise which is an additional aspect to be considered. The cost of constructing 1 km of vertical seawall ranges from USD0.4 to USD27.5 million. The rising sea level urges for adaptation measures to combat coastal groundwater salinization, where the aquifers are exposed. The cost of adaptation measures such as submerged and hydraulic barriers to preserve coastal groundwater reservoirs ranges from USD27 million to USD5.5 billion.

Groundwater is the cheapest source of water supply. Climate-resilient groundwater aquifers provide long-term resource availability which are abundant in the tropics. Such groundwater resources must be investigated and further developed in Malaysia. Groundwater resources require financial investment for development, management, protection strategies, and monitoring networks to realise their full potential as a key cost-optimal adaptation option. Non-conventional groundwater extraction can also help to mitigate global climate change by providing clean renewable energy.

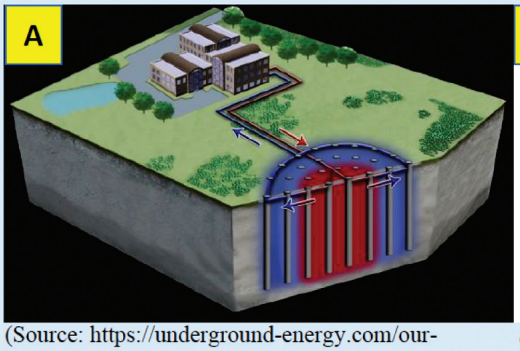
** Groundwater development and production inflation rate (2008: 1 USD ~ 3.33 MYR; 2010: 1 USD ~ 3.22 MYR; 2014: 1 USD ~ 60.994 INR). Off-river storage construction and operational cost inflation rate (2015: 1 USD ~ 6.45 CNY; 2019: 1 USD ~ 4.09 MYR). Adaptation cost inflation rate (2012; 1 USD ~ 0.85€)

Source: UK Environment Agency, 2007; Stek, 2008; Air Kelantan, 2009; Linham et al., 2010; Liu et al., 2013; Narayanamoorthy, 2014; Davidsen et al. 2015; Yang, 2018; Selangor Journal, 2019.

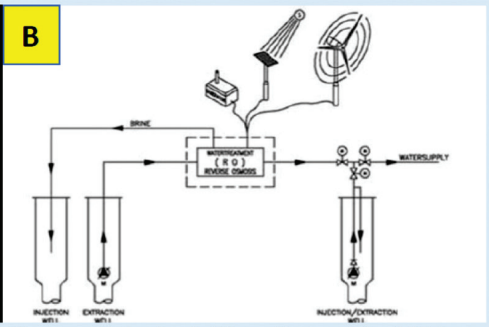
to delineate climate resilient groundwater resources in both these river basins. Overall, groundwater management needs to be improved, including better planning and siting of monitoring wells.

Increasingly, the non-conventional use of groundwater resources for climate change adaptation such as Aquifer Thermal storage for heating and cooling (ATES) (Fleuchaus et al., 2018), renewable energy and water (RENEW), CO_2 storage and managed artificial recharge and storage (MARS) programmes are becoming common (Casanova et al., 2016). Such non-conventional uses offer climate change mitigation benefits and must be explored for urban water supply as well as in the agricultural, rural, tourism and industrial areas (**Box 4**). In addition, a groundwater adaptation plan including critical water level (CWL) monitoring within unconfined aquifers should be developed for immediate implementation.

BOX 4: GROUNDWATER AND RENEWABLE ENERGY



(Source: https://underground-energy.com/our-technology/btes/)



(Source: Netherlands Water Partnership, 2007)

(Source: Netherlands Water Partnership, 2007)

Aquifer Thermal Energy Storage (ATES) is mainly implemented to decarbonise the thermal energy sector and achieve climate change mitigation targets (see A). The technology involves injection and withdrawal of groundwater to temporarily store the heat and cold in the subsurface. Requirements include (a) unconsolidated aquifer, (b) low groundwater flow, (c) high permeabilities, (d) geochemical conditions that prevent clogging and corrosion of wells, and (e) deep systems within sandstone or highly fractured rocks. The advantages of this technology include minimal groundwater contamination and depletion, energy savings between 40% and 70%, and capital cost that is expected to decline with increasing system size. The ATES has a lifetime of approximately up to 50 years if managed well. The lack of proper legislation is a daunting challenge. Technical issues such as clogging of wells and heat exchangers, corrosion of wells, unbalance between stored heat and cold, and swelling of clay minerals can be overcome by careful pre-investigation and appropriate operational design.

Renewable Energy and Water (RENEW) is the use of renewable energy to optimize groundwater resources (see B). Desalination of brackish groundwater in water-stressed regions can reduce water shortage issues. There are currently three renewable energy systems feasible for desalination of groundwater: solar photovoltaic, thermal processes and wind. These systems are economically promising for rural areas facing severe water scarcity, where the use of public electric grid is not cost-effective or feasible. The technology can also help to reduce non-revenue water since water supply from treatment plants are vulnerable to long-distance water conveyance. This approach is ideal for rural areas, to enhance the use of renewable energy and meet growing water demands with a lower carbon footprint compared to conventional technologies.

Carbon dioxide (CO_2) storage within a deep confined aquifer is a feasible solution to reduce emissions into the atmosphere (see C). Other solutions include subsurface storage within depleted gas fields, enhanced oil recovery and enhanced coal bed methane. Nevertheless, the storage potential and long-term stability remain a major challenge. Storage specific remediation plans are critical before the CO_2 injection process. Promising approaches can be further monitored using a telemetric system. It is a cost-efficient and robust mechanism designed for early leak detection.

Source: Snijders et al., 2003; Andersson, 2007; Netherlands Water Partnership, 2007; Dickinson et al., 2009; Godschalk and Bakema, 2009; Preene and Powrie, 2009; Novo et al., 2010; Andersson et al., 2013; Lee, 2013; Bloemendal et al., 2014; Sommer, 2015; Fleuchaus et al., 2018; Myers et al., 2020.

The investment for better adaptation technology in the country could start with more widespread implementation of a tertiary wastewater treatment plant that could further eliminate nutrient load from the wastewater before being released back to the river may (Muyibi et al., 2008). This should be expanded to address the aspect of contaminated soils to address the threat to future safety and quality of water resources. Technologies to effectively remediate contaminated soils have been widely explored the developed countries, including phytoremediation of soils contaminated with multiple pollutants (Tripathi et al., 2015). In order to perform a more effective appraisal of future risk to pollutant mobilisation, more inclusive monitoring information on sources of pollutant is needed from both the point-sources and non-point sources. Such pollutant sources include agricultural inputs, wastewater and sewage and sediment loading to soils, as well as acidification inputs from greenhouse gases that needs further study.

There is a need for improved downscaled climate change models to perform effective catchment projection, as the coupling of these models with a hydrological model results in amplified uncertainties. Such coupled models should be used judiciously for decision-making at the river-basin level. Other approaches using existing and expanded climate services should be explored, particularly for early warnings. For example, susceptibility modelling should be further expanded to determine the spatial and temporal status of land, soil and water resources quality. This is critical for identifying risks associated with natural hazard triggered technological accidents (NATECH) involving the releases of hazardous materials. As flood events become more intense and the extent of flood-prone areas expands, there may be an increasing risk of NATECH events, especially in areas that have never been flooded before or when the flood level exceeds current protection. The consideration of climate change impacts of NATECH risk is important and should be taken into account in the integration of disaster risk reduction and climate change adaptation. Translational research projects drawing on a multi-disciplinary framework are imperative for this purpose.

5.4 Focus Group Discussions and Surveys (Scope 4)

Focus group discussions were held with senior management of the Malaysian Meteorological Department (MET Malaysia), National Water Research Institute of Malaysia (NAHRIM), Department of Mineral and Geoscience Malaysia (JMG) and Malaysian Green Technology and Climate Change Centre (MGTC) as well as experts from Universiti Kebangsaan Malaysia and University of Malaya and the ASM, among others. The information from the focus group discussions was supplemented with key issues from 12 events organised by other parties, to delineate sector-based priorities with respect to climate change (**Appendix A**). A survey of the private sector by Climate Governance Malaysia (CGM) and youths by the Malaysian Youth Delegation (MYD) provided empirical data on priorities for the water sector. Citizens Assembles were also convened in Langkawi, Sabah and Sarawak to obtain insights from the communities.

5.4.1 Stakeholders Perspectives

The focus group discussions covered stakeholder perspectives on climate actions, climate modelling, the status of the groundwater, ocean and marine biodiversity, emerging public health issues as well as low carbon and disaster resilient cities in Malaysia. Broader themes such as disaster risks, adaptation planning, resilience building, financing climate action, insurance, health, nature-based solutions in urban planning and food security were also mentioned.

In many of these sessions, the issue of extreme weather was highlighted. The most common impact of extreme weather reported in Malaysia are floods, with over 1000 events reported between 2005 and 2019 (Seadpri-UKM Database, 2020). Government agencies such as the Department of Irrigation and Drainage (JPS) conduct extensive studies on floods; the findings are available in their library. However, the prevailing view is that that open-source data on hazards and risks of extreme climate events are not easily available in

Malaysia. Accessibility and availability of data is a common challenge emphasised in all sessions that were convened and covered. With respect to health, stakeholders were of the view that extreme weather events contribute to increased risks of water-borne and water related diseases, as well as increased levels of water contamination, particularly in areas where piped water is not available.

There is a poor appreciation of the difference between climate modelling and impact modelling in the country, specifically among decision makers. Typically, climate models and impact models are run separately. Some impact models such as hydrological models rely on climate information. However, there are many impact models that demarcate areas, where a hazard may occur based on contributing surficial and subsurface characteristics and processes. In such impact models, near-term climate information (days and months) is important to provide early warnings; an example being the magnitude of rainfall for landslides. Climate modelling and its downscaled products, particularly on rainfall, are associated with high levels of uncertainties and this is acknowledged by the modelling community. When climate models are linked to impact models, the uncertainties are amplified. Downscaled climate models cannot be used in the same way as weather forecasting models and end-users should be well-informed of the shortcomings. This is particularly important for impact modelling at the river basin and city scales. In addition, current climate models need to be improved though incorporating ocean atmospheric interactions, as these affect modelling accuracy in the coastal regions.

The private sector has a high level of awareness of climate change and stressed their dissatisfaction regarding the poor accessibility to information on hazards and risks of disasters in Malaysia. A survey of 53 respondents comprising primarily senior personnel at the directors' level revealed that 70% of the respondents were aware that their business and industry would be affected by climate change (CGM, 2020). About 80% wanted more information on the impact of climate change on water shortages and potential river basins that would be affected (**Figure 10**). Meanwhile, over 70% of the respondents were interested in information on high level of air pollution levels, extreme weather events, increased likelihood of diseases and supply chain disruptions. Other areas of interest include loss of forest ecosystems, areas susceptible to flooding, impact on agriculture and associated sectors as well as power disruption, among others.

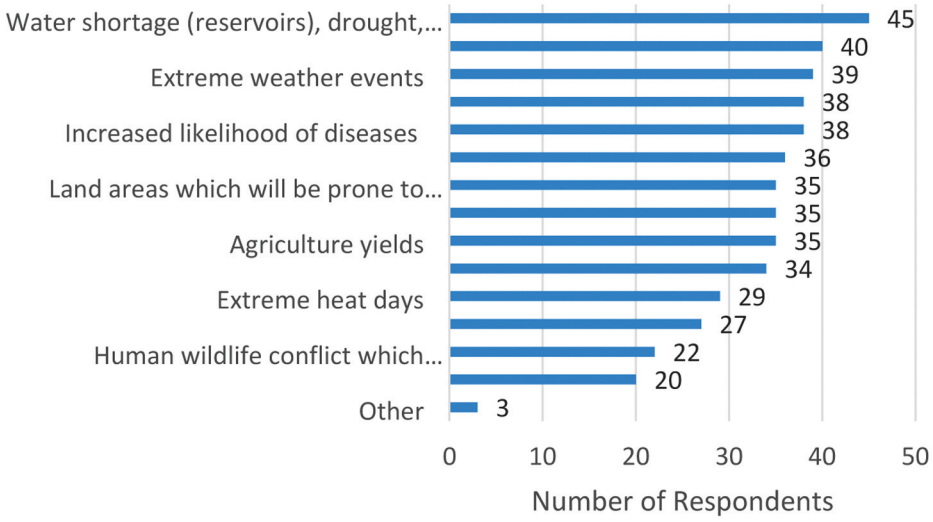


Figure 10 Level of Interest in Information on Risks Arising from Global Warming of 1.5°C in the Malaysian Private Sector (*Source*: CGM, 2020)

The youths in urban areas have experienced both water rationing and floods. A survey of 168 respondents below the age of 35 where almost 90% are degree holders, revealed that urban youths have experienced water rationing (65%) and floods (45%). Approximately 52% of the respondents believe that the government should aim to limit global warming to below 1.5°C, while about 14% are not aware of targets and their implications. This indicates a need for awareness building on the topic of global warming and climate change. However, a majority of the respondents are well aware of the risks associated with extreme weather. Water security is a major concern in relation to climate change, in addition to sea level rise, biodiversity loss and food security (**Figure 11**). The government is perceived to be responsible for ensuring reliable access to drinking water and sanitation, collaborating across sectors and groups to solve water-related issues and hazards and planning for climate change impacts. The private sector and individual citizens are also generally regarded being responsible but to a lesser extent. With respect to responses, while IWRM (76%) is the most popular, Integrated River Basin Management (IRBM) is the least favoured (49%) (**Figure 12**). This indicates a disconnect in understanding IWRM and other water-related actions and concepts that require awareness building. Other responses include technological innovation (70%), climate change adaptation planning (70%), nature-based solutions for coastal protection (66%) and water demand management (50%).

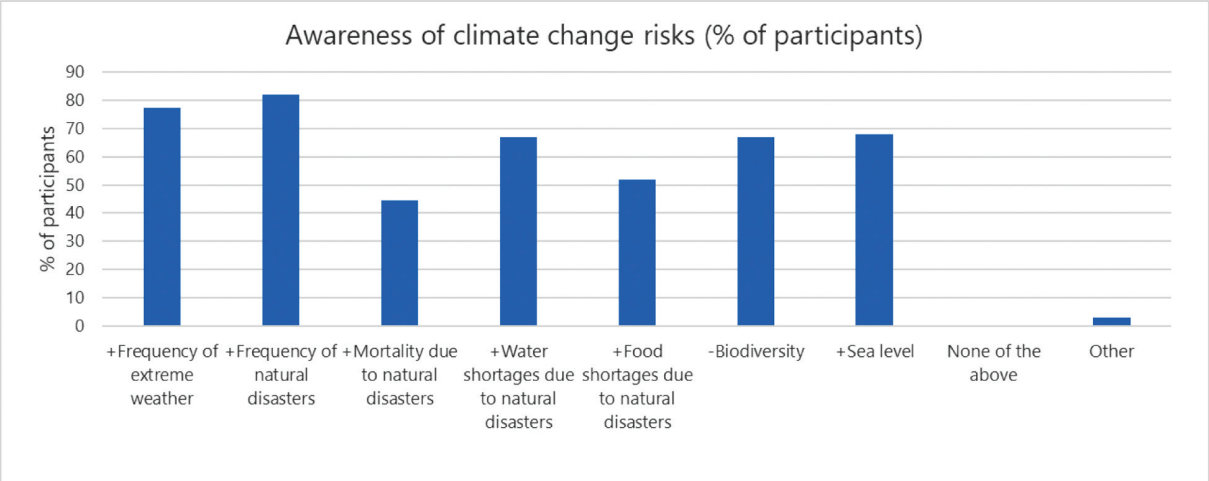


Figure 11 Level of Awareness of Climate Risks among Youths in Malaysia (*Source*: MYD, 2021)

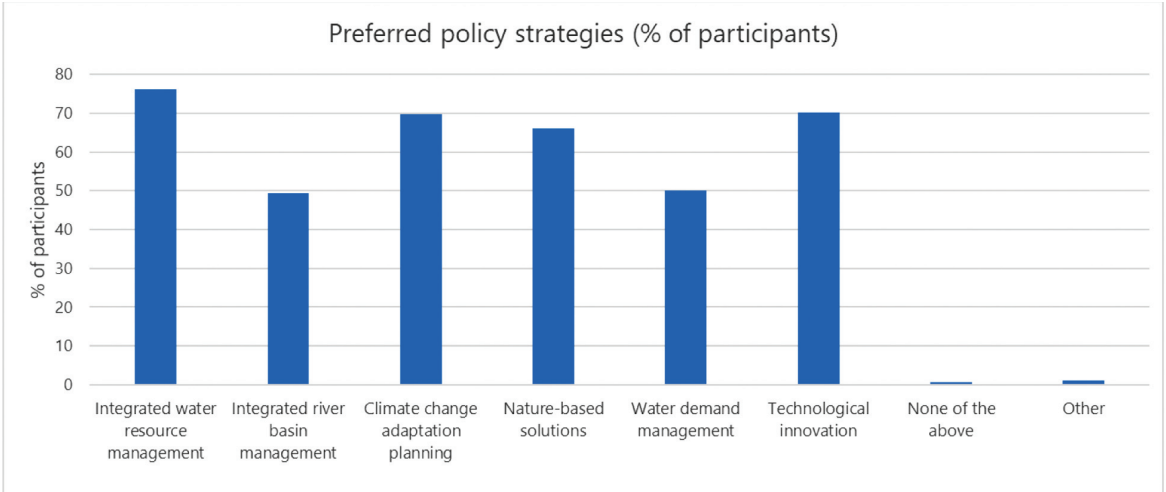


Figure 12 Preferred Responses to Climate Risks among Youths in Malaysia (*Source*: MYD, 2021)

Citizen assemblies usually aim to make recommendations to political leaders and illustrate how decision-making can follow an inclusive process of discussion, considering all perspectives carefully in light of evidence. Citizen assemblies were conducted in three areas, Langkawi Island, Sabah and Sarawak, to obtain the insight of local communities and stakeholders on issues related to the water sector and climate change in the context of impact and adaptation. The event in Langkawi Island was conducted face-to-face (**Figure 13**), while events in Sabah and Sarawak were conducted online due to the Covid-19 pandemic. Universities operating in the local areas took the lead in conducting the event with the Academy of Sciences of Malaysia.

The community and stakeholders at the local levels are already experiencing the impacts of climate variability and change. Each of the areas is affected differently (**Appendix B, C** and **D**). There are significant deficiencies in climate preparedness that is compounded by development activities. It was emphasised that it was required to have both top-down and bottom-up approaches for adaptation. The potential to enhance co-production of both scientific and experiential knowledge at the local level was also highlighted. Moving forward, the involvement of universities operating in the three local areas are critical for advancing this agenda.

Figure 13 A Citizens Assembly was Convened on 10 and 11 April 2021 in Langkawi Island. Four Separate Sessions were Held Targeting the Community, Private Sector, Government and Non-Government Organizations that are based in the Island

5.4.2 Proposals

Information on hazards and risks of extreme climate events has to be made available to the public. A one-stop open source database is proposed to support the National Risk Register that is under the custodianship of NADMA. The information could encompass areas that are susceptible to flooding, landslides, coastal inundation, extreme weather events, air pollution levels, diseases, supply chain disruptions, deforestation, biodiversity loss, among others.

Public awareness of IWRM and IRBM and their linkages has to be enhanced. The importance of both IWRM and IRBM to address disaster risks and climate change impacts have to be transmitted to all stakeholders. Additionally, technological innovation and good practices in climate change adaptation planning, nature-based solutions for coastal protection and water demand management have to disseminated within the country and to the region.

Governance mechanisms should be strengthened to bring the voices of the community to the attention of decision-makers at all levels of government, from the district or city levels, to state and federal levels. There are many community-specific challenges faced at the local level that is expected to worsen with climate change. Genuine engagement is the pathway to seek sustainable solutions. In this context, a river basin management approach may offer new entry-points for the engagement of multiple stakeholders including agencies, the private sector, youths, civil society organizations and the community. These stakeholders have to be linked to district offices, local authorities as well as state and federal agencies operating at the district level. A river basin platform would also serve to strengthen interagency collaboration, infuse a broader perspective and strengthen the existing and proposed programmes to tackle disaster and climate risks and its impacts to the health and wellbeing of the local communities.

5.5 Consultation with Stakeholders and Experts (Scope 5)

The fifth scope covers conducting strategic consultative workshops targeting key stakeholders from multiple levels and sectors with the aim of finalising the proposed strategies and initiatives of the nation's water sector transformation. Several ministries, agencies and civil society organisations (CSOs) were consulted via online sessions for this purpose (**Appendix E**). All the sessions were convened by the ASM in collaboration with selected parties. The topics selected were guided by findings from the previous scopes, primarily the literature and policy review, case study and stakeholder perspectives.

5.5.1 Strategic Consultations

The strategic consultation on "Climate Change and Groundwater" was held on 14 December 2020, convened in collaboration with the Department of Mineral and Geoscience Malaysia (JMG), Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM), Geological Society of Malaysia (GSM) and Institute of Geology Malaysia (IGM). The consultation was aimed to scope the role of the groundwater sector in contributing to WST2040, in the advent of climate change. Hydrogeologists shared potential areas in which they could contribute towards developing groundwater resources in Malaysia. The strategic consultation was followed by bilateral discussions with JMG and ASM Fellows on 17 May 2021 drawing on the findings of the groundwater status for the Selangor and Muda River Basins. This discussion served as a preparation for the Groundwater Roadmap Consultation, which was jointly convened by the ASM and JMG on 24 May 2021, where Task Force Members participated at the invitation of the JMG. The Consultation was co-chaired by Academician Datuk Fateh Chand FASc and Mr. Zamri bin Ramli, the Deputy Director General (Corporate and Mineral Economy) of JMG. Also present were the officers from other agencies, i.e. KASA, JPS, NAHRIM, MOH, MAFI and MYSA. Inputs from the event related to climate change have been integrated with other findings, to propose strategies and initiatives for the nation's water sector transformation.

The strategic consultation on "Climate Change Adaptation and Disaster Risk Management" was conducted on 25 February 2021 in collaboration with the National Disaster Management Agency (NADMA) Malaysia, the Academy of Risk Management Malaysia and Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM). The purpose of the consultation was to present the current status of climate change and risk management practices and seek inputs to transform disaster risk management in Malaysia in the advent of climate change. The opening speech was delivered by YBhg. Datuk Dr. Aminuddin bin Hassim, the Director General of NADMA. A key recommendation from the event was required for a major pilot initiative on disaster risk financing that provides social protection. Community-based activities including drills to engage stakeholders in disaster-prone areas across all phases of disaster management. The need for capacity building for disaster managers for area-specific risk at all levels was also emphasised. It was also noted that increasing information access to the public on hazards and risks of extreme climate was important to promote risk informed actions.

The strategic consultation on "Mainstreaming Climate Change in Public Health" was held on 10 May 2021 in collaboration with the Ministry of Health. The opening remarks was delivered by YBhg. Datuk Dr. Hishamshah bin Mohd Ibrahim, the Deputy Director General of Health (Research and Technical Support). The aim was to gather input and recommendations on health-related issues to support the nation's water sector transformation. The consultative session involved health officers from the Disease Control Division, Planning Division, Engineering Service Division, States' Occupational and Environmental Health Unit and Institute for Medical Research (IMR). The follow-up included a series of bilateral discussions to finalize and complete the draft Roadmap. A total of six bilateral discussions have been conducted thus far involving the senior management of MOH from the Disease Control Division, Planning Division, Engineering Service Division, Director of IMR, researchers from Universiti Kebangsaan Malaysia as well as Fellows of the ASM.

The stakeholder engagement on "Impact of Climate Change on Marine Biodiversity in Malaysia" was conducted on 5 July 2021. The multilateral engagement involved experts and representatives from the Ministry of Environment and Water (KASA), Department of Fisheries Malaysia, Universiti Malaya, Universiti Kebangsaan Malaysia, Universiti Malaysia Terengganu, Universiti Sains Malaysia, Malaysian Society of Marine Science, World Wildlife Fund Malaysia, Sahabat Alam Malaysia and Malaysian Nature Society. The main objective of the stakeholder engagement was to gather constructive feedback from the key stakeholders on the impacts of climate change on ocean and marine biodiversity in Malaysia. There is a lack of comprehensive understanding on the current state of coastal adaptation impacts, food security, marine biodiversity and food chains, ecosystems services. Long-term data on key oceanic parameters such as sea surface temperature, acidity, fugacity of carbon dioxide and dissolved oxygen are also limited. This is an unfortunate situation as Malaysia is one of the global marine biodiversity hotspots with livelihoods that depend on the ocean. Such information is important to decipher the impact of climate change on marine ecosystems and distinguish climatic signals from inter-annual variability and effects of development.

5.5.2 Key Recommendations

Global warming of 1.5ºC and associated extreme events are expected to worsen water related disasters including water stress in selected areas, and contribute to increased water borne diseases. Transformative actions are required to diversify water supply sources, identify emerging disaster risks and enhance the adaptive capacity of all stakeholders. A preliminary set of key recommendations are grouped into five focus areas of (i) people, (ii) governance, (iii) information and RDIC, (iv) finance, and (v) infrastructure and technology. The summary of key recommendations that have been proposed from the study as strategies, programmes and initiatives is presented in **Table 4**.

Table 4 Summary of Key Recommendations from the Study that have been Proposed as Strategies, Programmes and Initiatives

Focus Area	Proposed Strategies, Programmes and Initiatives (**not included in the 12th Malaysia Plan)
People	**Enhancing community engagement and capacity in disaster management** • Community-based activities including drills to engage stakeholders in disaster-prone areas across all phases of disaster management • Capacity building for disaster managers in local authorities and operational agencies for area-specific risk and simulation exercises with multiple partners • Increasing information access to the public through a one-stop open source data hub on hazards and risks of extreme climate, to promote risk informed actions** **Empowering people for strengthening adaptive capacity to climate change** • Awareness training and community-based adaptation efforts to engage local communities in vulnerable areas to build climate resilience • Technical capacity building across relevant sectoral ministries and agencies at all levels for adaptation planning, implementation and reporting • Competency training and certification for environmental professionals with knowledge of climate and disaster risks • Community-based adaptation for the water sector in river basins to promote engagement of multiple stakeholders • Technical capacity building for health professionals on management of climate sensitive diseases and outbreaks during disasters • Capacity building of trainers and teachers on climate change and sustainable water resources management • Public awareness on IWRM, IRBM and their linkages to disaster risks and climate change impacts** **Strengthening technical capacity of operational agencies at the river basin level**** • Workforce availability of multi-sectoral operational agencies at the river basin level** • Capacity building for integrating disaster risks and long-term climate hazards through spatial integration** • Capacity building of sectoral aspects in operational agencies at the river basin level** • Transdisciplinary technical skill-sets in operational agencies focusing on near term disaster risks and long term climate**
Governance	**Strengthening governance and partnerships at all levels** • National policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR • Human capital for state and local levels, to further improve the efficiency of disaster response measures** • Adaptation actions, implementation, monitoring and reporting of climate change adaptation progress at all levels • Climate change adaptation centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for informed decision-making at all levels** **Adopting integrated approaches for climate adaptation and disaster risk reduction** • Land use and spatial planning governance at all levels for integrating climate adaptation and disaster risks • Guidelines for disaster resilience cities to address climate extremes and integration of low carbon cities, sponge city and smart city for nation-wide adoption • Smart partnerships and coordination platforms to strengthen the health, disaster and climate nexus • Partnerships, coordination platforms and framework for integrating climate and disaster risks • Framework for integrating adaptation and risk reduction measures for surface and subsurface geological hazards to be incorporated in the revision of all relevant spatial plans** • Comprehensive groundwater governance at all levels to support conjunctive use of surface water and groundwater for implementing IWRM** • Establishing a river basin platform for strengthening vertical and horizontal interactions to advance integration of disaster and climate risks**

Table 4 Continued

Focus Area	Proposed Strategies, Programmes and Initiatives (**not included in the 12th Malaysia Plan)
	Strengthening regional linkages on disaster risks, climate change and IWRM • International linkages on disaster management for joint technical programmes and simulation exercises • Enhance linkages to regional platforms on disaster risks, climate change and IWRM in ASEAN** • Promote existing practices and technology to become a regional hub**
Information & RDIC	**Implementing evidence-based and risk-informed actions** • Multi-hazard risk management and vulnerability assessment for extreme events and cascading hazards, high-risk and sensitive areas and communities • Establishing a multi-hazard data centre and risk register platform for efficient information sharing and risk communication through use of ICT • Streamlining land use planning for river basins and administrative boundaries** • Monitoring and assessment of emerging groundwater hazards to improve groundwater management and disaster preparedness** **Enhancing capability for data driven decision making** • Weather, climate and geophysical information services for water related hazards such as flood, drought and tsunami • Climate science and modelling for planning and implementation to support decision-making at the river-basin level** • Climate change impacts on water resources and supply at the river basin scale • Smart technology for irrigation systems and crop production • Public health emergency preparedness, climate-disease surveillance and coordination of environmental health data **Assimilating knowledge to improve planning and implementation** • Vulnerability, hazards and emerging issues to address the impact of climate change and disasters • Strategic and emerging issues across terrestrial margins and oceans** • Pollutant mobilisation by floodwaters due to climate extremes**
Finance	**Investing in disaster risk management** • Disaster Risk Financing and Social Protection • Mainstreaming disaster risk management in public investment** • Investing in climate resilient groundwater resources for economic growth in water stressed areas** **Strengthening financial capacity for climate resilience** • Climate resilient and environment-friendly financing and alternative sources of income • Sector-based financing initiative**
Infrastructure and Technology	**Enhancing early warning systems and disaster response** • Framework for subsurface geological hazards and early warning for better preparedness of at-risk communities** • Land use climate change scenario planning model and decision-support system for development control** • Intensify research on health and climate-sensitive diseases due to loss of biodiversity, ecosystem degradation and climate change • Deploy big data analytics and artificial intelligence in forecasting and early warning systems to enable better prediction and reduction of disaster risks

Table 4 Continued

Focus Area	Proposed Strategies, Programmes and Initiatives (**not included in the 12th Malaysia Plan)
	Developing sustainable infrastructure with cost effective technology • Infrastructure and technology for flood and coastal protection. • Health, water, food and energy nexus at the river basin level. • IoT for the agriculture and forest sectors to build climate resilience. • Risk reduction and adaption for strategic infrastructure. • Increasing groundwater infrastructure for rural and water stressed areas to manage water stress during dry spells, including green technologies that provide co-benefits to climate change adaptation.** • Advancing technology to improve water quality through widespread implementation of tertiary wastewater treatment plants to further eliminate nutrient load from the wastewater before being released back to the river.** **Enhancing disaster preparedness and recovery** • Resilient construction guidelines and standards for retrofitting and reconstruction of damaged buildings and infrastructure. • Aligning recovery from COVID-19 to build climate resilience and improve public health for sustainable development. • Framework for build back better approach to be adopted in enhancing resilience against climate change and disasters. • Enhance nature-based adaptation and risk reduction measures through green cover expansion and coastal improvement as well as watershed, wetlands and river conservation. • Leverage technologies, including artificial intelligence sensors and alert systems to ensure more effective disaster response.** **Enhancing conservation measures as an adaptation option for coastal and marine areas**** • Expand regional climate models to include more ocean components and at higher resolution.** • Leverage technologies, including artificial intelligence and sensors to support marine monitoring stations and regulate over fishing.** • Establish a national coordinating centre to enhance ocean governance and support a multi-disciplinary platform on climate change, marine resources and ocean ecosystems.**

5.5.2.1 People

Enhancing community engagement and capacity in disaster management: There is need to engage all stakeholders, particularly the community and the private sector in disaster-prone areas across all phases of disaster management. In line with the expected increase of intensity and frequency of weather and climate extremes, disaster managers in local authorities and operational agencies need capacity building in understanding the risk that is specific to their areas. The public should also be aware and have access to information regarding their exposure and vulnerability to hazards and risks so that they can take appropriate actions. In addition, the importance of both IWRM and IRBM to address disaster risks and climate change impacts have to be transmitted to all stakeholders.

Increasing information access to the public is also critical for all phases of disaster management. A one-stop open-source data hub is proposed to improve public access to information on hazards and risks of extreme climate events and strengthen disaster prevention and preparedness. The data hub could be linked to the database of multiple custodian agencies to provide information on areas that are susceptible to flooding, landslides, coastal inundation, extreme weather events, air pollution levels, diseases, supply chain disruptions, deforestation, biodiversity loss, among others. The database could also contain information on technological innovation and good practices in climate change adaptation planning, nature-based solutions for coastal protection and water demand management have to be disseminated within the country and to the region.

Empowering people for strengthening adaptive capacity to climate change: Local communities should be made aware of their vulnerability to climate change in the long-term, so that they can engage in community-based adaptation efforts towards building resilience. For example, the public should be made aware of the importance of groundwater in the context of climate change and its potential to replenish river water resources that are increasingly polluted. Current examples of groundwater use that serve as climate change adaptation measures should be highlighted. Examples include the use of groundwater in mosques that is common in Melaka and the application of groundwater in peat fire management in Selangor. The importance of monitoring groundwater quality and preventing over extraction to avoid land subsidence, as reported in the Kota Bharu region, need to be clarified through structured awareness programmes. In addition, the community needs to be continuously engaged in groundwater management programmes to ensure pollution is in control at source and recharge areas. Awareness should also focus on emerging groundwater hazards in coastal areas due to sea level rise and measures to prevent fire and water shortage during extended dry spells through improved groundwater management in peatlands, agriculture and plantations.

There is also a need to improve the understanding of disaster risks, climate change and health nexus. The public must be informed of the importance of standard operating procedures implemented by the authorities to optimise water consumption during dry spells and water related disasters. Other than that, awareness of the consumption of contaminated shellfish from harmful algae blooms in river deltas should also be enhanced. The target group should include local communities, small and medium industries, migrant communities, school children, and tertiary students among others. Programmes that focus on "training the trainers" such as teachers, religious heads, community leaders and the media through the engagement of public and private universities, CSOs and the private sector should be promoted. Higher education institutions in Malaysia should collaborate with each other, and with government agencies and other stakeholders, to take a river basin approach or local scale approach in addressing the multi-faceted impacts of climate change. New strategies that emphasise people-friendly approaches within specific river-basins by integrating official flood, drought, biodiversity impact, and disaster-related health management programmes should be considered. Disaster risks, climate change and health nexus awareness should be incorporated as a mandatory component in all river basin studies and water projects, to promote engagement of multiple stakeholders. There is an urgent need to enhance the technical capacity across relevant sectoral ministries and agencies for adaptation planning, implementation and reporting. The competency of professionals in the environment, health and education sector on climate and disaster risks in the context of IWRM must also be further enhanced.

Strengthening technical capacity within operational agencies at the river basin level: The capacity of the current workforce of multi-sectoral operational agencies in ensuring uninterrupted services at the river basin level should also be reviewed. Technical capacity building is required for development management for urban planners, supporting staff and related professional bodies in addressing near term disaster risks and long-term climate hazards through spatial integration. Furthermore, operational agencies at the river basin level need technical capacity building with respect to development management, water quality management, climate sensitive diseases, emergency preparedness, management of outbreak during disasters, health promotion and risk communication to the media. The technical capacity of water managers in delineating and developing climate resilient groundwater aquifers for near-term climate change adaptation must also be enhanced. This includes enhancing the competence on aspects such as recharge capacity, aquifer transboundary management and groundwater abstraction, protection of well-head sites and recharge areas as well as other good practices. Transdisciplinary technical skill-sets are required in various agencies focusing on near term disaster risks and long term climate risks. Such skill-sets include cultivating long-term partnerships, engagement and mobilisation of local champions, particularly community leaders and youths through volunteer programmes.

5.5.2.2 Governance

Strengthening governance and partnerships at all levels: An overall framework that draws on river basins as the basic spatial unit will facilitate the linking of disaster risk reduction in the near term and climate change adaptation in the long term. The formulation of a national policy on disaster risk management could provide the basis for further development of multi-level disaster resilience plans and legislation. Sufficient human capital for state and local levels is critical to further improve the efficiency of disaster response measures in enabling the country to speed-up preparations for global warming of 1.5ºC and its expected extreme events.

The development of a national adaptation plan is essential for providing the pathway for adaptation actions and their implementation. This requires coordination of various policies and strategies that are underway with respect to water resources, disaster risk and other sectors impacted by climate change. There is also a need for a framework to monitor the implementation as well as to evaluate and report progress on the effectiveness of such policies and programmes across sectors at all levels in enabling adaptation. This is to ensure that the national resources are used efficiently, and able to detect any shortfalls immediately and plan for alternative solutions. Furthermore, the dynamicity of climate change requires multi-sectoral and multi-disciplinary knowledge to handle emerging issues. This calls for a dedicated climate change centre in the long-term, to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for informed decision-making at all levels.

Currently, the National Water Balance Management System (NAWABS) and National Flood Forecasting and Warning System (NaFFWS) have been adopted as an adaptive approach at the river basin level. The operational NAWABS system is located in Sungai Muda, Sungai Kedah, Sungai Kelantan, Sungai Bernam and Sungai Melaka. On the other hand, the operational NaFFWS is located along the Sungai Kelantan, Sungai Pahang and Sungai Terengganu. These adaptive strategies should be expanded to other river basins, especially those that are vulnerable to climatic risk. This framing requires the support of local stakeholder inputs and involvement of scientists and practitioners from multiple disciplines and multiple sectors. The step-wise adaptation approach could be implemented commencing with measures to strengthen disaster risk governance, upgrade disaster related decision-making systems, build capacity, promote strategic investment in climate proofing infrastructure and assets, enhance and mainstream groundwater usage and promote nature-based solutions, among others.

Groundwater offers a cost-optimal adaptation option to handle emerging water stress situations. Transitioning groundwater management to groundwater governance facilitates the participation of multilevel stakeholders through a dedicated coordinating committee at the national and state levels. Groundwater governance involves coordination of a range of stakeholders including political, social, economic, environmental and institutional actors in managing surface water resources and aquifers for providing water supply. This approach involves scientists, policy makers, industry and end-users by considering each of their concerns on the freshwater supply. It contributes to alleviating the burden of responsibilities that the government needs to carry in ensuring sustainability of groundwater resources. A comprehensive approach is required for the development of groundwater as a resource, requiring a national policy on groundwater and aquifer management.

State agencies should be facilitated to play a leading role in groundwater development and management as complementary to surface water to strengthen climate change adaptation in the water sector. Lembaga Urus Air Selangor (LUAS) can serve as a model for this purpose. State level groundwater management committees should be established, modelled after the State Agriculture Committee, State Industrial Committee, to enable coordination among the various agencies gazette groundwater recharge areas. Legal instruments should be further strengthened at the State levels, in line with IWRM to ensure a holistic coverage of issues

on groundwater resources, including integrated management of aquifers. Detailed action plans are required to prioritise groundwater development regimes for climate change adaptation, targeting areas with poor water services or experience frequent disruptions due to river pollution. In this context, groundwater quality standard should be advanced for nationwide adoption.

The National Water Resources Policy (2012) has incorporated strategic actions to protect surface and groundwater connectivity but these are insufficient. Policy instruments can only provide the direction and strategy to intervene in existing government processes, so as to set the course needed to help the government reset or introduce a course of action or move forward. They cannot be used to regulate an issue. In line with the National Policy on the Environment (2002), appropriate plans drawing on a comprehensive inventory are required for protection of the groundwater resources and recharge areas. As an interim measure, the National Water Council should set up a standing committee on groundwater co-led by the Ministry of Energy and Natural Resources (KeTSA) and Ministry of Environment and Water (KASA) to oversee integrated management of groundwater, to support transformation of the water sector by 2040. As water is a State matter, the Federal Government can support the planning and provide much needed intelligence to facilitate sustainable management of groundwater resources.

Adopting integrated approaches for climate adaptation and disaster risk reduction: Resilience has become a key challenge for cities, especially in the face of climate change. Cities that are resilient have the capacity to adapt and transform in the face of adversity. They can plan for the expected as well as the unexpected by involving and preparing communities to effectively prevent and respond to current and emerging hazards. The National Low Carbon Cities Master Plan (NLCCMP) should be reviewed to include the component of climate and disaster resilience. This will ensure that the efforts undertaken by cities to reduce their carbon footprint are in complement by reducing their exposure to disaster risks due to climate extremes. With global warming of 1.5ºC, guidelines are required for disaster resilience cities to address climate extremes and integration of low carbon cities, sponge city and smart city for nation-wide adoption. A framework is also required for integrating adaptation and risk reduction measures for surface and subsurface geological hazards, to be incorporated in the revision of all relevant spatial plans. The guidelines should also encompass measures for handling emergencies such as breakdown of water supply and pollution of water sources; promoting conjunctive use of surface water and groundwater for implementing IWRM. Other important aspects include monitoring of water related disasters and emerging health issues, early warnings and risk communication, in collaboration with climate service providers.

A river basin management approach offers new entry-points for the engagement of multiple stakeholders including agencies, the private sector, youths, civil society organisations and the community. In order for their voices to be heard, these stakeholders have to be linked to State water and land use planning authorities, district offices, local authorities as well as state and federal agencies operating at the district level. This calls for strengthening of land use and spatial planning governance at all levels for integrating climate adaptation and disaster risks. Partnerships, coordination platforms and a common framework are required for integrating climate and disaster risks and strengthening enforcement through sharing of workforce from relevant agencies. A river basin platform would also serve to strengthen interagency collaboration, infuse a broader perspective and strengthen existing and proposed programmes that benefit the well-being of local communities. Smart partnerships facilitated at such coordination platforms could strengthen the health, disaster and climate nexus. Initially, this requires vulnerability assessment programmes that encompass all population groups (e.g. children, adults, elderly, pregnant women) on health components or indicators related to climate change and their adaptive capacity, in order to plan for the preparation of health system for future health scenarios.

A National Committee has been proposed to connect all water-related government agencies including state water authorities to promote collaboration and reduce the overlapping responsibilities. This is particularly relevant for improved monitoring of persistence pollutants, especially in hot-spot areas with extensive industrial, agriculture and livestock farming as well as aquaculture. The committee could be supplemented with a strong inter-ministerial and multi-stakeholder platform for addressing disaster risk reduction, which comprises all relevant sectors, such as planning and finance, education, health, agriculture, food security, environment, emergency response, appropriately including private sector, scientific and other civil society representation. The Malaysian DRR Platform (myDRR), which is currently under the aegis of NADMA, could be further strengthened and expanded for this purpose.

Strengthening regional linkages on disaster risks, climate change and IWRM: Malaysia could leverage linkages at the regional level to promote good practices and technology and become a regional hub in ASEAN. Hosting of technical programmes and simulation exercises are a means to foster linkages on disaster management and show-case existing expertise. Malaysia is relatively less advanced in implementing climate change adaptation strategies related to IWRM, despite being among the top three in IWRM practices related to disaster risk reduction. Strengthening climate change adaptation through a river basin framework will facilitate the country to leverage its existing IWRM practices, strategies and technology for disaster risk reduction, to become a regional hub. Active participation in global adaptation networks is also critical, covering sectors such as water, agriculture, health and humanitarian response. The Humid Tropic Centre operated by Department of Irrigation and Drainage (JPS) could play a role for this purpose.

5.5.2.3 Information and RDIC

Implementing evidence-based and risk-informed actions: Expanding climate services for early warning supports multi-hazard risk management and vulnerability assessment for extreme events and cascading hazards in high-risk and sensitive areas and communities, in preparation for global warming of 1.5ºC. Climate services provided by the MET Malaysia should be expanded, to support risk-informed actions at the river-basin level. This is particularly relevant for floods via the National Water Balance Management System (NAWABS) under the Department of Irrigation and Drainage (JPS), and landslides via the Mineral and Geoscience Department (JMG). Monitoring and assessment of emerging groundwater hazards also serves to improve groundwater management and disaster preparedness at the river basin level. The establishment of a multi-hazard data centre and risk register platform for efficient information sharing and risk communication through use of information and communications technology (ICT) is also crucial. In addition, the land use planning for river basins and administrative boundaries should be streamlined through initial pilots.

Enhancing capability for data driven decision making: Weather, climate and geophysical information services are important for data driven decision making on water related hazards such as flood, drought and tsunami. Climate services are required to augment information from downscaled climate change models, specifically on rainfall at the river basin level, which should be used judiciously due to amplified uncertainties. Currently, NaFFWS uses National Weather Prediction (NWP) to forecast a weekly precipitation pattern while the NAWABS utilise The National Centres for Environmental Prediction (NCEP) climate forecast system (CFS2) data to forecast drought events 3 months in advance. The feasibility of increased groundwater use, by itself or in conjunction with surface water resources, needs to be explored. This is especially important within the Selangor River Basin, since all available surface water has been fully investigated and utilised largely for potable water supply. Forest reserves in the Selangor and Muda Rivers Basins must be protected as groundwater recharge zone areas. The impacts of extreme rainfall patterns and salinisation of existing groundwater resources need to be identified. In addition, investment is required to delineate climate resilient groundwater resources in both these river basins. Overall, groundwater management needs to be improved, including better planning and siting of monitoring wells. Priority should also be given for developing the

groundwater service sector, for expanding the mineral water industry. Groundwater resources non-conventional use for climate change adaptation such as ATES, RENEW, CO2 Storage and MARS programme for urban water supply, agricultural and rural areas, tourism and industry sector also need to be explored. Other aspects that require enhanced capability include smart technology for irrigation systems and crop production in the agriculture sector as well as public health emergency preparedness, climate-disease surveillance and coordination of environmental health data.

Assimilating knowledge to improve planning and implementation: A well-coordinated multi-disciplinary research agenda is required on vulnerability, water related hazards and emerging issues associated with climate change and disasters. The research includes aspects related to aquifer depletion, saltwater intrusion, aquifer recharge and maintenance of groundwater recharge areas. Tools and infrastructure for groundwater pollution monitoring as well as management and rehabilitation programmes are also relevant.

New approaches are critical for identifying risks associated with natural hazard triggered technological accidents (NATECH), which are integral for a comprehensive adaptation plan. These approaches should involve multidisciplinary experts and practitioners, coupled with local knowledge to inform adaptation plans and policies. An example is knowledge assimilation on pollutant mobilisation by floodwaters due to climate extremes. This requires whole lifecycle monitoring of pollutants for more efficient management of industrial waste. The knowledge would improve existing master plan for wastewater treatment plants and policies for more sustainable water resource management. Proper and thorough clean-up of contaminated sites such as ex-mining areas would be necessary to avert adverse effects in the future. The identification of emerging non-point sources of soil pollution such as agricultural land is also important. This is to prevent pollutant mobilisation by floodwaters due to climate extremes, which would then contaminate surface water resources.

There is a need to strengthen local research evidence on climate change impacts on health and well-being. Currently, most of the climate change health impacts have been informed by global research data. Local research on the impacts of climate change on health (e.g. changing pattern of water-borne diseases), and wellbeing (e.g. education, basic services) across different social groups are lacking, causing inadequate data evidence to plan and support decision-making at the national level. Local situations (e.g. indigenous population) may be different from the status in other countries, which may require alternative unique approaches to address. Collaborations involving government, universities, public sectors, non-governmental organisations and local communities require advancement to address these challenges.

5.5.2.4 Finance

Investing in disaster risk management: Disaster risk financing enables the availability of funds to meet the incurred losses and ensure that the funds reach the recipient within the time required. Insurance against natural perils such as floods can help to accelerate economic and social recovery after disaster occurrence as the insurance compensation received provides immediate liquidity, thus expediting the recovery process. However, the use of insurance as a risk financing tool needs to be further explored to ensure that it is integrated with the existing social protection programme. Mainstreaming disaster risk management in public investment will benefit the economy by increasing the resilience of capital stock, keeping public debt dynamics manageable, and maintaining adequate fiscal space to cope with disasters. Disaster risk financing is effective when the focus on prevention, early warning and keeping community infrastructure safe is also prioritised to reduce future risk.

Investing in climate resilient groundwater resources is critical for economic growth. The cost of shifting supplies from groundwater to surface water for groundwater-dependent communities is high, particularly

with increasing pollution of rivers. The cost of water disruption to economic activities compared to the cost of investing in groundwater to supplement surface water, to prevent interruption of services has been examined in detail. Additionally, the costs involved in handling emerging climate change threats to groundwater specifically in areas where this is the primary source of water supply must be estimated. In this context, investments should be channelled to delineate groundwater resources and aquifers that maintain their recharge capacity under extreme climate conditions. Furthermore, an inventory of groundwater-dependent communities in Malaysia has to be developed to enable a comprehensive economic evaluation. Fiscal and non-fiscal benefits to encourage groundwater development and maintenance of aquifer systems are also required to be identified, with initial funding sourced from the Federal Government.

Strengthening financial capacity for climate resilience: Climate resilient and environment-friendly financing and alternative sources of income should be explored in the country. Investment should be channelled for strengthening of adaptive capacity to build resilience at all levels. Aligning the global recovery from COVID-19 and response to climate change offers a triple win: improving public health, creating a sustainable economy and building resilience. An option to be considered is to expand the national health financing system through alternative pathways such as establishing a national social health insurance mechanism that covers medical expenditures and improving technical capacity to implement and operate health financing.

5.5.2.5 Infrastructure and Technology

Enhancing early warning systems and disaster response: The deployment of big data analytics and artificial intelligence has great potential in forecasting and early warning systems, to enable better prediction and reduction of disaster risks. An area to be explored is in developing a framework for subsurface geological hazards and early warning for better preparedness of at-risk communities in cities. In addition, land use scenario planning model and decision-support system for development control could also be enhanced through artificial intelligence.

Technology advancement would also benefit the management of health and climate-sensitive diseases due to loss of biodiversity, ecosystem degradation and climate change. Early warning systems for extreme weather conditions such as flood and drought need to be further explored.

Developing sustainable infrastructure with cost effective technology: Cost effectiveness is imperative in deploying infrastructure and technology for flood and coastal protection. Feasibility study needs to take into account in-depth cost comparisons across a range of technologies with due consideration to the social and environmental benefits. The citizens' assemblies have revealed that local stakeholder engagement and acceptance is paramount to ensure long-term effectiveness of solutions. There is a need for infrastructure and technology to support expansion and implementation of the health, water, food and energy nexus at the river basin level. Technology is also required for the agriculture and forest sectors to build climate resilience as well as risk reduction and adaptation for strategic infrastructure.

A priority climate change adaptation measure for groundwater development is the enhancement of quality infrastructure in water stressed and rural areas. A range of technologies should to be identified and deployed to support the integrated management of an aquifer system. These include technologies for groundwater mapping and assessment, metering and licensing, monitoring of groundwater extraction and recharge, as well as hard-rock aquifer delineation. Where available, existing hydrological stations could provide water level and rainfall measurement; an integrated monitoring system to manage the water resources availability and quality would benefit NAWABS. The development of surface water – groundwater conjunctive use of water technologies for agriculture water management and desalination of brackish/saline ground water using membrane technology technologies are important climate adaptation measures. Green technologies

are particularly important for groundwater development, to enable the country to meet commitments to the Paris Agreement. An example is the use of appropriate renewable energy to drive submersibles in food production.

Widespread implementation of tertiary wastewater treatment plants could further eliminate nutrient load from the wastewater before being released back to the river. These include upgrading water treatment plants and improving low-cost technology, including monitoring instruments for water quality and use of local approaches. The issue of contaminated soils to address the threat to future safety and quality of water resources also requires attention. Technologies for effectively remediating contaminated soils have been widely explored in the developed countries, including phytoremediation of soils contaminated with multiple pollutants. In order to perform a more effective appraisal of future risk to pollutant mobilisation, more inclusive monitoring information on sources of pollutant is needed, from both the point-sources and non-point sources. Examples include wastewater treatment and water resources management systems to improve efficiency and emergency response capacity.

Climate proof health infrastructure is critical as projections suggest that there will be increased frequency and intensity of heavy rains, floods and landslides. These events may cause damage to public facilities and infrastructures that pose hazards and disrupt population's well-being, especially in the deprived areas such as islands and rural areas that already have limited access to basic resources such as safe water, food and healthcare services. Therefore, it is imperative that basic public infrastructures such as health facilities, schools, access pathways in these vulnerable areas are adequately supplemented with climate proof structures, designs, and systems that enable sustainable deliveries of necessities, healthcare (e.g. disease outbreak management, chronic disease medications) and children's education especially during prolonged climate events. The latest flood technologies such as demountable flood barriers, mobile flood barriers and flood pumps should also be explored as future adaptation options.

Enhancing disaster preparedness and recovery: The projection for increased frequency and intensity of climate extreme events requires the country to enhance preparations and put in place adequate recovery measures. In this context, a framework for build back better approach should be adopted in enhancing resilience against climate change and disasters. Additionally, guidelines are required for resilient construction and standards for retrofitting and reconstruction of damaged buildings and infrastructure should be developed. A pathway forward is to align recovery from Covid-19 towards building climate resilience and improving public health for sustainable development.

Nature-based adaptation and risk reduction measures are recommended to be explored moving forward. These include the expansion of green cover, coastal improvement as well as watershed, wetlands and river conservation. Technologies, including artificial intelligence sensors and alert systems could contribute to ensure more effective preparedness, response and recovery.

Enhancing conservation measures as an adaptation option for coastal and marine areas: Conservation measures are important adaptation options for addressing the impacts of sea-level rise in coastal and marine areas. In the absence of long-term monitoring data and downscaled climate projections for on key oceanic parameters, a step-wise adaptation approach is proposed. Adaptation measures in the water and coastal sectors that are not carefully considered could lead to maladaptation in the coastal and marine areas. Examples include the construction of engineering structures to manage water stress and protect coastal communities that result in trade-offs to marine biodiversity. Programmes on conservation include the following:

- Promote aquaculture to increase the acceptability of cultured fish species among the next generation of Malaysian fish consumers so as to alleviate pressure on marine fish diversity
- Strengthen adaptive capacity through improved understanding of climate change impacts on marine biodiversity, food security and coastal livelihoods; and training of marine ecologists and taxonomists
- Expand regional climate models to include more ocean components at higher resolution
- Leverage technologies, including artificial intelligence and sensors to support marine monitoring stations for measuring key oceanic variables; establish a "Seafood Rating System" to protect oceans and ensure future seafood supplies; and regulate overfishing to ensure the long-term biological and economic sustainability of fisheries in Malaysia.
- Establish a national coordinating centre to enhance ocean governance and support a multi-disciplinary platform on climate change, marine resources and ocean ecosystems for promoting cross-collaboration, resource mobilisation, regional cooperation and informed decision-making.

5.6 Roadmap for WST2040 (Scope 6)

The sixth scope is to prepare a complete Roadmap for the National Agenda on the Water Sector Transformation 2040 for key ministries and agencies to take into account climate change impacts and strengthen adaptation for the water sector. The Roadmap was populated according to the five focus areas drawing on findings of the study. Input from the assessment of literature and review of policies (Scope 1), regional assessment (Scope 2), case studies (Scope 3) as well as multiple engagement sessions and elicitation techniques (Scope 4) have been integrated, and in consultation with stakeholders (Scope 5), and these are expressed as key recommendations. The recommendations served as input to strengthen existing programmes and identify new initiatives for the immediate-term (12th MP), near-term (13th MP), medium-term (14th MP) and long-term (15th MP) (**Appendix F** and **G**). Further consultations were held for this purpose with KASA, NADMA, MOH and JMG/KeTSA, among others. The immediately implementable projects for the 12th MP are presented in **Table 5**, and the strategies, targets, KPIs and proposed budget for 12-15th MPs are depicted in **Tables 6** to **9**. The key targets and KPIs based on the amalgamation of several relevant programmes and the numbers of the targets and KPIs proposed in the Roadmap are presented in **Tables 10** and **11**.

Table 5 Immediate Implementable Projects for the 12th MP

Focus Area	Program/Initiative
People	• Community-based activities including drills to engage stakeholders in disaster-prone areas across all phases of disaster management. • Capacity building for disaster managers in local authorities and operational agencies for area-specific risk and simulation exercises with multiple partners. • Awareness training and community-based adaptation efforts to engage local communities in vulnerable areas to build climate resilience. • Technical capacity building across relevant sectoral ministries and agencies at all levels for adaptation planning, implementation and reporting. • Competency training and certification for environmental professionals with knowledge of climate and disaster risks. • Community-based adaptation for the water sector in river basins to promote engagement of multiple stakeholders. • Technical capacity building for health professionals on management of climate sensitive diseases and outbreaks during disasters. • Capacity building of trainers and teachers on climate change and sustainable water resources management. • Capacity building for urban planners, supporting staff and related professional bodies in spatial integration of DRR and CCA.

Table 5 Continued

Focus Area	Program/Initiative
Governance	• National policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR. • Adaptation actions, implementation, monitoring and reporting of climate change adaptation progress at all levels. • CCA centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for informed decision-making at all levels. • Land use and spatial planning governance at all levels for integrating climate adaptation and disaster risks. • Guidelines for disaster resilient cities to address climate extremes and integration of low carbon cities, sponge city and smart city for nation-wide adoption. • Smart partnerships and coordination platforms to strengthen the health, disaster and climate nexus. • Partnerships, coordination platforms and framework for integrating climate and disaster risks. • Comprehensive groundwater governance at all levels to support conjunctive use of surface water and groundwater for implementing IWRM.
Information & RDIC	• Multi-hazard risk management and vulnerability assessment for extreme events and cascading hazards, high-risk and sensitive areas and communities. • Establish a multi-hazard data centre and risk register platform for efficient information sharing and risk communication through use of ICT. • Streamline land use planning for river basins and administrative boundaries. • Monitoring and assessment of emerging groundwater hazards to improve groundwater management and disaster preparedness. • Weather, climate and geophysical information services for water related hazards such as flood, drought and tsunami. • Climate science and modelling for planning and implementation to support decision-making at the river-basin level. • Climate change impacts on water resources and supply at the river basin scale. • Smart technology for irrigation systems and crop production. • Public health emergency preparedness, climate-disease surveillance and coordination of environmental health data. • Vulnerability, hazards and emerging issues to address the impact of climate change and disasters. • Strategic and emerging issues across terrestrial margins and oceans.
Finance	• Disaster risk financing and social protection. • Mainstreaming disaster risk management in public investment. • Climate resilient and environment-friendly financing and alternative sources of income.
Infrastructure & Technology	• Framework for subsurface geological hazards and early warning for better preparedness of at-risk communities. • Infrastructure and technology for flood and coastal protection. • Health, water, food and energy nexus at the river basin level. • IoT for agriculture and forest sectors to build climate resilience. • Risk reduction and adaption for strategic infrastructure. • Resilient construction guidelines and standards for retrofitting and reconstruction of damaged buildings and infrastructure.

Table 6 Strategies, Targets and KPIs for the 12th MP

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
People	Enhancing Community Engagement and Capacity in Disaster Management	Community-based activities including drills to engage stakeholders in disaster-prone areas across all phases of disaster management.	Number of activities including drills conducted.	NADMA	9.00
		Capacity building for disaster managers in local authorities and operational agencies for area-specific risk and simulation exercises with multiple partners.	Number of officers trained.	NADMA	6.00
	Empowering People for Strengthening Adaptive Capacity to Climate Change	Awareness training and community-based adaptation efforts to engage local communities in vulnerable areas to build climate resilience.	Number of CEPA activities being conducted.	KASA	3.00
		Technical capacity building across relevant sectoral Ministries and agencies at all levels for adaptation planning, implementation and reporting.	Number of officers trained.	KASA	3.00
		Competency training and certification for environmental professionals with knowledge of climate and disaster risks.	Achieving and sustaining accreditation of MS ISO/IEC 17025 by 2022.	KASA	0.37
		Community-based adaptation for the water sector in river basins to promote engagement of multiple stakeholders.	Number of river basin.	KASA	50.00
		Technical capacity building for health professionals on management of climate sensitive diseases and outbreaks during disasters.	Number of officers trained.	MOH	0.21
		Capacity building of trainers and teachers on climate change and sustainable water resources management.	Number of trainers, teachers trained; number of webinars conducted; 100% polytechnic community colleges curriculum embedded green element; Graduate Employability and Employer Satisfaction Index.	KASA	112.40

Table 6 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
	Strengthening Capacity of Operational Agencies at the River Basin Level	Capacity building for urban planners, supporting staff and related professional bodies in spatial integration of DRR and CCA.	Annual training of 10 urban planners from PLANMalaysia; 14 urban planners from PLANMalaysia at State (including Sabah & Sarawak); 10 urban planners form local authorities; 10 urban planners from Malaysian Institute of Planners; and 10 Institute of engineers, institute of landscape architects, institute of surveyors.	NADMA	4.00
Governance	Strengthening Governance and Partnerships at All Levels	National policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR.	Number of policy/ plans/legislations.	NADMA	1.00
		Adaptation actions, implementation, monitoring and reporting of climate change adaptation progress at all levels.	NAP and Implementation Plan.	KASA	3.50
		CCA centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for informed decision-making at all levels.	1 coordinating centre with staff.	KASA	2.00
	Adopting Integrated Approaches for Climate Change	Land use and spatial planning governance at all levels for integrating climate adaptation and disaster risks.	1 study on governing and financing mechanism.	NADMA	1.00
	Adaptation and Disaster Risk Reduction	Guidelines for disaster resilient cities to address climate extremes and integration of low carbon cities, sponge city and smart city for nation-wide adoption.	Guidelines, integrated plans; 2 pilots and 5 cities and townships per year.	NADMA/ KASA/ KPKT	5.00
		Smart partnerships and coordination platforms to strengthen the health, disaster and climate nexus.	Coordination platform for environmental health; DWQA gazetted and enforced.	MOH/KASA	80.47

Table 6 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
Information & RDIC	Implementing Evidence-Based and Risk-Informed Actions	Multi-hazard risk management and vulnerability assessment for extreme events and cascading hazards, high-risk and sensitive areas and communities.	Tsunami risk assessment, NRR for man-made and rapid & slow on-set risk assessments.	NADMA/ MOSTI/ KASA/KeTSA	4.50
		Establish a multi-hazard data centre and risk register platform for efficient information sharing and risk communication through use of ICT.	Feasibility and upgrading of NDCC.	NADMA	62.00
		Streamline land use planning for river basins and administrative boundaries.	2 River Basin Land Use Planning and Management Plan; 1 Coastal Land Use Planning and Management Plan; Land Use Scenario Planning Model and decision support system able to be replicated to other areas with similar characteristics; 1 local plan in an urban setting; 1 local plan in a rural setting; 1 special area plan in the coastal area; and 1 special area plan in high-density city; 1 special area plan for hilly terrain area.	NADMA	15.00
		Monitoring and assessment of emerging groundwater hazards to improve groundwater management and disaster preparedness.	National Groundwater Information System (NaGWiS)	NADMA/ KeTSA	3.50
	Enhancing Capability for Data Driven Decision-making	Weather, climate and geophysical information services for water related hazards such as flood, drought and tsunami.	Two radar stations for each MP; implementation of cloud computing technology and fulfil the requirements of green technology in ICT.	KASA/ NADMA	147.50

Table 6 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
		Climate science and modelling for planning and implementation to support decision-making at the river-basin level.	Multiscale global model specifically focusing on the tropics and a semi-hemispheric global model.	KASA/ NADMA	62.29
		Climate change impacts on water resources and supply at the river basin scale.	Number of river basin.	KASA/ KeTSA/MAFI/ NADMA	120.00
		Smart technology for irrigation systems and crop production.	IoT technology in pepper farming throughout Malaysia; water footprint for 1kg of natural rubber produced.	MPIC/KASA	1.65
		Public health emergency preparedness, climate-disease surveillance and coordination of environmental health data.	New emerging pollutants; DWQI reporting; Environmental Health Information System.	MOH/KASA/ NADMA	17.80
	Assimilating Knowledge to Improve Planning and Implementation	Vulnerability, hazards and emerging issues to address the impact of climate change and disasters.	5 parameters of hydroclimate dataset output; 3 system/tools output; 5 technical assessment reports on vulnerability, impact & adaptation assessment (VIA); produced detailed local SLR, coastal sediment transport inundation and flood prone potential across 14 states in Malaysia; numerical modelling assessment on selected coastal and river mouth nationwide; 151 projects approved in Malaysia Grand Challenge (MGC).	KASA/ NADMA/ MOH/MOSTI	531.00

Table 6 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
Finance	Investing in Disaster Risk Management	Disaster risk financing and social protection.	Framework	NADMA	3.00
		Mainstreaming disaster risk management in public investment.	1 competition per year; 5 development grant per year; 1 seminar per year; 10 research grant per year, 1 joint colloquium per year; 1 compilation of research per year.	NADMA/ KASA	13.30
	Strengthening Financial Capacity for Climate Resilience	Climate resilient and environment-friendly financing and alternative sources of income.	Feasibility study	KASA	3.00
Infrastructure & Technology	Enhancing Early Warning Systems and Disaster Response	Framework for subsurface geological hazards and early warning for better preparedness of at-risk communities.	Subsurface geology model and inventory; Subsurface DRM Plan and Early Warning System; and Regulations for Subsurface Development for Greater Kuala Lumpur.	NADMA/ KeTSA	10.00
	Developing Sustainable Infrastructure with Cost Effective Technology	Infrastructure and technology for flood and coastal protection.	Number of river basin; best solution for flood door; identify national shoreline changes.	KASA/ NADMA/ KeTSA/MAFI/ MOSTI	424.00
		Health, water, food and energy nexus at the river basin level.	Coverage of clean water supply for rural area with water treatment system.	MOH/KASA	89.44
		IoT for agriculture and forest sectors to build climate resilience.	Fertigation system; water recycle system; wastewater treatment system; scientific journal and Best Management Practices (BMP) of oil palm on peatland.	MPIC/MOSTI/ KASA	274.00

Table 6 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
	Enhancing Disaster Preparedness and Recovery	Resilient construction guidelines and standards for retrofitting and reconstruction of damaged buildings and infrastructure.	MS EN 1998-2, Design of Structure for earthquake resistance.	NADMA	0.35

Table 7 Strategies, Targets and KPIs for the 13th MP

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
Finance	Enhancing Community Engagement and Capacity in Disaster Management	Community-based activities including drills to engage stakeholders in disaster-prone areas across all phases of disaster management.	Number of activities including drills conducted.	NADMA	9.00
		Capacity building for disaster managers in local authorities and operational agencies for area-specific risk and simulation exercises with multiple partners.	Number of officers trained.	NADMA	6.00
	Empowering People for Strengthening Adaptive Capacity to Climate Change	Awareness training and community-based adaptation efforts to engage local communities in vulnerable areas to build climate resilience.	Number of CEPA activities conducted.	KASA	5.00
		Technical capacity building across relevant sectoral Ministries and agencies at all levels for adaptation planning, implementation and reporting.	Number of officers trained.	KASA	5.00
		Community-based adaptation for the water sector in river basins to promote engagement of multiple stakeholders.	Number of river basin.	KASA	50.00
		Technical capacity building for health professionals on management of climate sensitive diseases and outbreaks during disasters.	Number of officers trained.	MOH	0.10
		Capacity building of trainers and teachers on climate change and sustainable water resources management.	Number of trainers, teachers trained; number of webinars conducted; one blueprint.	KASA	8.02

Table 7 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
	Strengthening Capacity of Operational Agencies at the River Basin Level	Capacity building for urban planners, supporting staff and related professional bodies in spatial integration of DRR and CCA.	Annual training of 10 urban planners from PLANMalaysia; 14 urban planners from PLANMalaysia at State (including Sabah & Sarawak); 10 urban planners form local authorities; 10 urban planners from Malaysian Institute of Planners; and 10 Institute of engineers, institute of landscape architects, institute of surveyors.	NADMA	5.00
Governance	Strengthening Governance and Partnerships at All Levels	National policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR.	Number of policy/ plans/legislations	NADMA	5.00
		Human capital for state and local levels, to further improve the efficiency of disaster response measures.	Number of offices in every state.	NADMA	50.00
		Adaptation actions, implementation, monitoring and reporting of climate change adaptation progress at all levels.	NAP and Implementation Plan.	KASA	10.00
		CCA centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for informed decision-making at all levels.	1 coordinating centre with staff.	KASA	20.00
	Adopting Integrated Approaches for Climate Change Adaptation and Disaster Risk Reduction	Guidelines for disaster resilient cities to address climate extremes and integration of low carbon cities, sponge city and smart city for nation-wide adoption.	Guidelines, integrated plans; 2 pilots and 5 cities and townships per year.	NADMA/ KASA/ KPKT	10.00

Table 7 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
		Smart partnerships and coordination platforms to strengthen the health, disaster and climate nexus.	Coordination platform for environmental health; DWQA gazetted and enforced.	MOH/KASA	77.10
	Strengthening Regional Linkages on Disaster Risks, Climate Change and IWRM	International linkages on disaster management for joint technical programmes and simulation exercises.	1 international programme per year.	NADMA	2.00
Information & RDIC	Implementing Evidence-Based and Risk-Informed Actions	Multi-hazard risk management and vulnerability assessment for extreme events and cascading hazards, high-risk and sensitive areas and communities.	Expansion to local level scale and coverage of more hazards (natural & man-made) for selected pilots.	NADMA/ MOSTI/ KASA/ KeTSA	15.00
		Establish a multi-hazard data centre and risk register platform for efficient information sharing and risk communication through use of ICT.	Centralised disaster information platform.	NADMA	150.00
		Streamline land use planning for river basins and administrative boundaries.	1 local plan in an urban setting; 1 local plan in a rural setting; 1 special area plan in the coastal area; and 1 special area plan in high-density city; 1 special area plan for hilly terrain area.	NADMA	2.50
		Monitoring and assessment of emerging groundwater hazards to improve groundwater management and disaster preparedness.	National Groundwater Information System (NaGWiS); National Groundwater Monitoring System (NaGMiS) for groundwater hazards	NADMA/ KeTSA	65.00

Table 7 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
	Enhancing Capability for Data Driven Decision-making	Weather, climate and geophysical information services for water related hazards such as flood, drought and tsunami.	Two radar stations for each MP; implementation of cloud computing technology and fulfil the requirements of green technology in ICT.	KASA/ NADMA	108.00
		Climate science and modelling for planning and implementation to support decision-making at the river-basin level.	Multiscale global model specifically focusing on the tropics and a semi-hemispheric global model.	KASA/ NADMA	175.00
		Climate change impacts on water resources and supply at the river basin scale.	Number of river basin.	KASA/ KeTSA/ MAFI/ NADMA	120.00
		Smart technology for irrigation systems and crop production.	Water footprint for 1kg of natural rubber produced; workshop to introduce new technology packages to pepper growers.	MPIC/KASA	0.17
		Public health emergency preparedness, climate-disease surveillance and coordination of environmental health data.	New emerging pollutants.	MOH/KASA/ NADMA	4.00
	Assimilating Knowledge to Improve Planning and Implementation	Vulnerability, hazards and emerging issues to address the impact of climate change and disasters.	Equipped Malaysian Waters with Physical Oceanographic Sensors; 5 guidelines, procedures and technical documents; 2 Subject Matter Expert (SME) in Hydroclimate & 2 pilot site of nature based solution (NBS) adaptation projects; 5 technical reports including CCA-DRR frameworks	KASA/ NADMA/ MOH	57.70

Table 7 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
			for water related disaster; 1 Subject Matter Expert (SME) in Hydrodynamic & 1 SME in Green Technology & Ecosystem-based Approach (EbA); 5 parameters of hydroclimate dataset output; 3 system/tools output; 5 technical assessment reports on vulnerability, impact & adaptation assessment (VIA); produced detailed local SLR, coastal sediment transport inundation and flood prone potential across 14 states in Malaysia; numerical modelling assessment on selected coastal and river mouth nationwide.		
Finance	Investing in Disaster Risk Management	Mainstreaming disaster risk management in public investment.	1 competition per year; 5 development grant per year; 1 seminar per year; 10 research grant per year, 1 joint colloquium per year; 1 compilation of research per year; sufficient fund to rural stakeholders for adoption and implementation of new technologies.	NADMA/ KASA/ MPIC	30.50

Table 7 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
Infrastructure & Technology	Enhancing Early Warning Systems and Disaster Response	Framework for subsurface geological hazards and early warning for better preparedness of at-risk communities.	Subsurface geology model and inventory; Subsurface DRM Plan and Early Warning System; and Regulations for Subsurface Development for Greater Kuala Lumpur, Ipoh, Johor Bahru, Penang, Kuching, Kota Kinabalu and all other states capital.	NADMA/ KeTSA	35.00
	Developing Sustainable Infrastructure with Cost Effective Technology	Infrastructure and technology for flood and coastal protection.	Number of river basin.	KASA/ NADMA/ KeTSA/ MAFI	110.00
		Health, water, food and energy nexus at the river basin level.	Coverage of clean water supply for rural area with water treatment system.	MOH/KASA	110.53
		IoT for agriculture and forest sectors to build climate resilience.	Approx. 50 nurseries house at MCB Bagan Datuk, Perak; water recycle system; IoT application on white pepper production in Sarawak (first phase) and Peninsular Malaysia (second phase)	MPIC/KASA	8.20

Table 8 Strategies, Targets and KPIs for the 14th MP

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
People	Enhancing Community Engagement and Capacity in Disaster Management	Community-based activities including drills to engage stakeholders in disaster-prone areas across all phases of disaster management.	Number of activities including drills conducted.	NADMA	9.00
		Capacity building for disaster managers in local authorities and operational agencies for area-specific risk and simulation exercises with multiple partners.	Number of officers trained.	NADMA	6.00
	Empowering People for Strengthening Adaptive Capacity to Climate Change	Awareness training and community-based adaptation efforts to engage local communities in vulnerable areas to build climate resilience.	Number of CEPA activities conducted.	KASA	5.00
		Technical capacity building across relevant sectoral Ministries and agencies at all levels for adaptation planning, implementation and reporting.	Number of officers trained.	KASA	5.00
		Community-based adaptation for the water sector in river basins to promote engagement of multiple stakeholders.	Number of river basin.	KASA	50.00
		Capacity building of trainers and teachers on climate change and sustainable water resources management.	Number of trainers, teachers trained; number of webinars conducted.	KASA	11.08
	Strengthening Capacity of Operational Agencies at the River Basin Level	Capacity building for urban planners, supporting staff and related professional bodies in spatial integration of DRR and CCA.	Annual training of 10 urban planners from PLANMalaysia; 14 urban planners from PLANMalaysia at State (including Sabah & Sarawak); 10 urban planners form local authorities; 10 urban planners from Malaysian Institute of Planners; and 10 Institute of	NADMA	5.00

Table 8 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
			engineers, institute of landscape architects, institute of surveyors.		
Governance	Strengthening Governance and Partnerships at All Levels	National policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR.	Number of policy/ plans/legislations	NADMA	5.00
		Human capital for state and local levels, to further improve the efficiency of disaster response measures.	Number of offices in every state.	NADMA	100.00
		Adaptation actions, implementation, monitoring and reporting of climate change adaptation progress at all levels.	NAP and Implementation Plan.	KASA	10.00
		CCA centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for informed decision-making at all levels.	1 coordinating centre with staff.	KASA	10.00
	Adopting Integrated Approaches for Climate Change Adaptation and Disaster Risk Reduction	Guidelines for disaster resilient cities to address climate extremes and integration of low carbon cities, sponge city and smart city for nation-wide adoption.	Guidelines, integrated plans; 2 pilots and 5 cities and townships per year.	NADMA/ KASA/ KPKT	10.00
		Smart partnerships and coordination platforms to strengthen the health, disaster and climate nexus.	Coordination platform for environmental health; DWQA gazetted and enforced.	MOH/KASA	77.00
	Strengthening Regional Linkages on Disaster Risks, Climate Change and IWRM	International linkages on disaster management for joint technical programmes and simulation exercises.	1 international programme per year.	NADMA	2.00

Table 8 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
Information & RDIC	Implementing Evidence-Based and Risk-Informed Actions	Multi-hazard risk management and vulnerability assessment for extreme events and cascading hazards, high-risk and sensitive areas and communities.	Expansion to local level scale and coverage of more hazards (natural & man-made).	NADMA/ MOSTI/ KASA/ KeTSA	20.00
		Establish a multi-hazard data centre and risk register platform for efficient information sharing and risk communication through use of ICT.	Maintenance and expansion to state level.	NADMA	50.00
		Monitoring and assessment of emerging groundwater hazards to improve groundwater management and disaster preparedness.	National Groundwater Information System (NaGWiS); National Groundwater Monitoring System (NaGMiS) for groundwater hazards	NADMA/ KeTSA	75.00
	Enhancing Capability for Data Driven Decision-making	Weather, climate and geophysical information services for water related hazards such as flood, drought and tsunami.	Two radar stations for each MP; implementation of cloud computing technology and fulfill the requirements of green technology in ICT.	KASA/ NADMA	118.00
		Climate change impacts on water resources and supply at the river basin scale.	Number of river basin.	KASA/ KeTSA/ MAFI/ NADMA	120.00
		Smart technology for irrigation systems and crop production.	Workshop to introduce new technology packages to pepper growers.	MPIC/KASA	0.10
		Public health emergency preparedness, climate-disease surveillance and coordination of environmental health data.	New emerging pollutants.	MOH/KASA/ NADMA	2.00

Table 8 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
	Assimilating Knowledge to Improve Planning and Implementation	Vulnerability, hazards and emerging issues to address the impact of climate change and disasters.	Equipped Malaysian Waters with Physical Oceanographic Sensors; 5 guidelines, procedures and technical documents; 2 Subject Matter Expert (SME) in Hydroclimate & 2 pilot site of nature based solution (NBS) adaptation projects; 5 technical reports including CCA-DRR frameworks for water related disaster; 1 Subject Matter Expert (SME) in Hydrodynamic & 1 SME in Green Technology & Ecosystem-based Approach (EbA); 5 parameters of hydroclimate dataset output; 3 system/tools output; 5 technical assessment reports on vulnerability, impact & adaptation assessment (VIA); produced detailed local SLR, coastal sediment transport inundation and flood prone potential across 14 states in Malaysia; numerical modelling assessment on selected coastal and river mouth nationwide.	KASA/ NADMA/ MOH	56.00
Finance	Investing in Disaster Risk Management	Mainstreaming disaster risk management in public investment.	1 competition per year; 5 development grant per year; 1 seminar per year; 10 research	NADMA/ KASA/ MPIC	33.00

Table 8 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
			grant per year, 1 joint colloquium per year; 1 compilation of research per year; sufficient fund to rural stakeholders for adoption and implementation of new technologies.		
Infrastructure & Technology	Enhancing Early Warning Systems and Disaster Response	Framework for subsurface geological hazards and early warning for better preparedness of at-risk communities.	Subsurface geology model and inventory; Subsurface DRM Plan and Early Warning System; and Regulations for Subsurface Development for Greater Kuala Lumpur, Ipoh, Johor Bahru, Penang, Kuching, Kota Kinabalu and all other states capital.	NADMA/ KeTSA	70.00
		Land use scenario planning model and decision-support system for development control.	7 Land use scenario planning model.	NADMA	7.00
	Developing Sustainable Infrastructure with Cost Effective Technology	Infrastructure and technology for flood and coastal protection.	Number of river basin.	KASA/ NADMA/ KeTSA/MAFI	110.00
		Health, water, food and energy nexus at the river basin level.	Coverage of clean water supply for rural area with water treatment system.	MOH/KASA	110.53
		IoT for agriculture and forest sectors to build climate resilience.	IoT application on white pepper production in Sarawak (first phase) and Peninsular Malaysia (second phase).	MPIC/KASA	0.20

Table 9 Strategies, Targets and KPIs for the 15th MP

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
People	Enhancing Community Engagement and Capacity in Disaster Management	Community-based activities including drills to engage stakeholders in disaster-prone areas across all phases of disaster management.	Number of activities including drills conducted.	NADMA	10.00
		Capacity building for disaster managers in local authorities and operational agencies for area-specific risk and simulation exercises with multiple partners.	Number of officers trained.	NADMA	8.00
	Empowering People for Strengthening Adaptive Capacity to Climate Change	Awareness training and community-based adaptation efforts to engage local communities in vulnerable areas to build climate resilience.	Number of CEPA activities conducted.	KASA	5.00
		Technical capacity building across relevant sectoral Ministries and agencies at all levels for adaptation planning, implementation and reporting.	Number of officers trained.	KASA	5.00
		Community-based adaptation for the water sector in river basins to promote engagement of multiple stakeholders.	Number of river basin.	KASA	50.00
		Capacity building of trainers and teachers on climate change and sustainable water resources management.	Number of trainers, teachers trained; number of webinars conducted.	KASA	14.34
	Strengthening Capacity of Operational Agencies at the River Basin Level	Capacity building for urban planners, supporting staff and related professional bodies in spatial integration of DRR and CCA.	Annual training of 10 urban planners from PLANMalaysia; 14 urban planners from PLANMalaysia at State (including Sabah & Sarawak); 10 urban planners form local authorities; 10 urban planners from Malaysian Institute of Planners; and 10 Institute of engineers, institute of landscape architects, institute of surveyors.	NADMA	5.00

Table 9 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
Governance	Strengthening Governance and Partnerships at All Levels	National policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR.	Number of policy/ plans/legislations	NADMA	5.00
		Human capital for state and local levels, to further improve the efficiency of disaster response measures.	Number of offices in every state.	NADMA	50.00
		Adaptation actions, implementation, monitoring and reporting of climate change adaptation progress at all levels.	NAP and Implementation Plan.	KASA	10.00
		CCA centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for informed decision-making at all levels.	1 coordinating centre with staff.	KASA	10.00
	Adopting Integrated Approaches for Climate Change Adaptation and Disaster Risk Reduction	Guidelines for disaster resilient cities to address climate extremes and integration of low carbon cities, sponge city and smart city for nation-wide adoption.	Guidelines, integrated plans; 2 pilots and 5 cities and townships per year.	NADMA/ KASA/ KPKT	10.00
		Smart partnerships and coordination platforms to strengthen the health, disaster and climate nexus.	Coordination platform for environmental health; DWQA gazetted and enforced.	MOH/KASA	77.00
	Strengthening Regional Linkages on Disaster Risks, Climate Change and IWRM	International linkages on disaster management for joint technical programmes and simulation exercises.	1 international programme per year.	NADMA	2.00
Information & RDIC	Implementing Evidence-Based and Risk-Informed Actions	Multi-hazard risk management and vulnerability assessment for extreme events and cascading hazards, high-risk and sensitive areas and communities.	Expansion to local level scale and coverage of more hazards (natural & man-made).	NADMA/ MOSTI/ KASA/ KeTSA	30.00

Table 9 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
		Establish a multi-hazard data centre and risk register platform for efficient information sharing and risk communication through use of ICT.	Maintenance and expansion to state level.	NADMA	50.00
		Monitoring and assessment of emerging groundwater hazards to improve groundwater management and disaster preparedness.	National Groundwater Information System (NaGWiS); National Groundwater Monitoring System (NaGMiS) for groundwater hazards	NADMA/ KeTSA	85.00
	Enhancing Capability for Data Driven Decision-making	Weather, climate and geophysical information services for water related hazards such as flood, drought and tsunami.	Two radar stations for each MP; implementation of cloud computing technology and fulfill the requirements of green technology in ICT.	KASA/ NADMA	94.00
		Climate science and modelling for planning and implementation to support decision-making at the river-basin level.	Multiscale global model specifically focusing on the tropics and a semi-hemispheric global model.	KASA/ NADMA	330.00
		Climate change impacts on water resources and supply at the river basin scale.	Number of river basin.	KASA/ KeTSA/ MAFI/ NADMA	120.00
		Smart technology for irrigation systems and crop production.	Workshop to introduce new technology packages to pepper growers.	MPIC/KASA	0.10
		Public health emergency preparedness, climate-disease surveillance and coordination of environmental health data.	New emerging pollutants.	MOH/KASA/ NADMA	2.00

Table 9 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
	Assimilating Knowledge to Improve Planning and Implementation	Vulnerability, hazards and emerging issues to address the impact of climate change and disasters.	Equipped Malaysian Waters with Physical Oceanographic Sensors; 5 guidelines, procedures and technical documents; 2 Subject Matter Expert (SME) in Hydroclimate & 2 pilot site of nature based solution (NBS) adaptation projects; 5 technical reports including CCA-DRR frameworks for water related disaster; 1 Subject Matter Expert (SME) in Hydrodynamic & 1 SME in Green Technology & Ecosystem-based Approach (EbA); 5 parameters of hydroclimate dataset output; 3 system/tools output; 5 technical assessment reports on vulnerability, impact & adaptation assessment (VIA); produced detailed local SLR, coastal sediment transport inundation and flood prone potential across 14 states in Malaysia; numerical modelling assessment on selected coastal and river mouth nationwide.	KASA/ NADMA/ MOH	49.00
Finance	Investing in Disaster Risk Management	Mainstreaming disaster risk management in public investment.	1 competition per year; 5 development grant per year; 1 seminar per year;	NADMA	5.00

Table 9 Continued

Focus Area	Strategy	Programmes/Initiatives	Targets/KPIs	Lead Authority	Proposed Budget (RM '000,000)
			10 research grant per year, 1 joint colloquium per year; 1 compilation of research per year; sufficient fund to rural stakeholders for adoption and implementation of new technologies.	NADMA/ KASA/ MPIC	34.00
Infrastructure & Technology	Enhancing Early Warning Systems and Disaster Response	Framework for subsurface geological hazards and early warning for better preparedness of at-risk communities.	Subsurface geology model and inventory; Subsurface DRM Plan and Early Warning System; and Regulations for Subsurface Development for Greater Kuala Lumpur, Ipoh, Johor Bahru, Penang, Kuching, Kota Kinabalu and all other states capital.	NADMA/ KeTSA	80.00
		Land use scenario planning model and decision-support system for development control.	7 Land use scenario planning model.	NADMA	7.00
	Developing Sustainable Infrastructure with Cost Effective Technology	Infrastructure and technology for flood and coastal protection.	Number of river basin.	KASA/ NADMA/ KeTSA/ MAFI	110.00
		Health, water, food and energy nexus at the river basin level.	Coverage of clean water supply for rural area with water treatment system.	MOH/KASA	110.53
		IoT for agriculture and forest sectors to build climate resilience.	IoT application on white pepper production in Sarawak (first phase) and Peninsular Malaysia (second phase).	MPIC/KASA	0.20

Table 10 Key WST2040 Targets and KPIs based on the Amalgamation of Several Relevant Programmes Proposed in the Roadmap

Focus Areas	Transformation Item	Measurement	Target	Baseline	12MP	13MP	14MP	15MP
People	Conduct community-based activities including drills to increase emergency response and climate adaptation efforts.	No. of programmes	30 programmes	-	5	7	8	10
	Build technical capacity of urban planners and land custodians for spatial integration of DRR and CCA at the river basin level.	No. of trainees	3500 trainees	-	750	850	950	950
Governance	Develop a national policy on disaster risk management (DRM), multi-level disaster resilience (DR) plans and law on DRR.	No. of policy No. of plans No. of law	1 DRM Policy 7 DR Plans 1 DRM Law	-	1 Policy on DRM[1] 1 DR Plan	2 DR Plans	1 Law on DRM 2 DR Plans	2 DR Plans
	Develop a national adaptation plan (NAP) and establish a coordinating centre for monitoring and reporting.	No. of plan No. of coordinating centre	1 NAP 1 CCA coordinating centre	-	1 NAP	1 coordinating centre with support staff	Review of NAP	Strengthe-ning and coordinating centre
Infrastructure & Technology	Multi-hazard data centre and monitoring of subsurface geological hazards for better preparedness of at-risk communities.	No. of cities	1 pilot city 5 state capitals	-	Greater Kuala Lumpur	Greater Kuala Lumpur, Ipoh, Johor Bahru, Penang	Penang, Kuching, Kota Kinabalu and monitoring of other cities	Kuching, Kota Kinabalu and regional technology transfer
	Improve low-cost technology approach and upgrade water treatment system for safe alternative rural water supply.	% of access to safe water in rural areas	100% access in rural areas	96.84%	98%[1]	-	-	-
Information & RDIC	Streamline land use planning and climate scenarios with IWRM, IRBM, ESAs, CCA and DRR.	No. of models for decision support system	4 River Basins and 4 coastal areas	-	Pilot for 1 River Basins	Pilot for 1 coastal area	Decision support system for 1 River Basins and 1 coastal area	Replicate in 2 River Basins and 2 coastal areas
	Strengthen meteorology and hazards early warning in river basins.	No. of River Basins	16 River Basins	-	8 River Basins	8 River Basins	Maintaining, upgrading and replication	Replication and regional technology transfer
Finance	Disaster risk financing and social protection.	No. of studies No. of pilots No. of programmes	1 study 1 pilot mechanism 1 national program	-	1 Feasibility study	1 Pilot for disaster risk transfer mechanism	Alternative funds for disaster relief and recovery	Replicate nation-wide
	Climate resilient and environment-friendly financing and alternative sources of income.	No. of studies No. of pilots No. of programmes	1 study 1 pilot mechanism 1 national program	-	1 Feasibility study	1 Pilot involving private sector, CSOs and individuals	Scale-up financing and investment	Replicate nation-wide

[1] Government of Malaysia 2021, Twelfth Malaysia Plan 2021-2025. Economic Planning Unit, Prime Minister's Department, Putrajaya.

Table 11 Numbers of Targets and Kpis based on the Programmes Proposed in the Roadmap

Focus Areas	12MP		13MP		14MP		15MP	
	Targets	KPIs	Targets	KPIs	Targets	KPIs	Targets	KPIs
People	12	12	10	10	8	8	8	8
Governance	6	6	7	7	7	7	7	7
Infrastructure & Technology	10	10	8	8	7	7	7	7
Information & RDIC	24	24	22	22	19	19	20	20
Finance	11	11	7	7	7	7	7	7
Total	**63**	**63**	**54**	**54**	**48**	**48**	**49**	**49**

6.0 WAY FORWARD – 8i ECOSYSTEM APPROACH

The range of key recommendations that have been identified cover all aspects of the 8i model of Nair (2011) within the five focus areas (**Figure 14**). The key recommendations served as a guide for the Ministries and agencies to prepare and finalise the Roadmap with respect to priority and urgency of action.

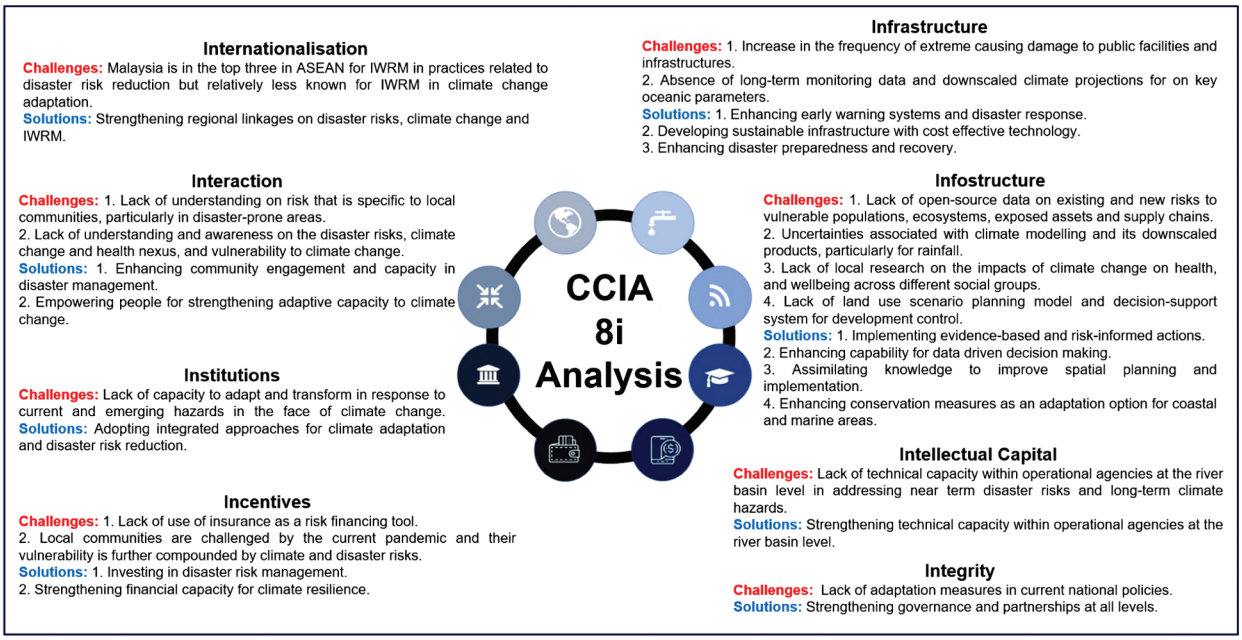


Figure 14 Overview of climate challenges and solutions according to the 8i Enablers for the Roadmap for the National Agenda on Water Sector Transformation 2040

7.0 CONCLUSIONS AND RECOMMENDATIONS

Climate change is projected to intensify extreme weather events, including higher temperatures and intense rainfall, which contribute to increased risk of disasters. Southeast Asia is projected to experience the largest impact on economic growth with global warming of 1.5ºC. Long dry periods without rain and low streamflow levels that intensify river pollutants are expected to worsen water stress conditions. Climatic hazards ranging from fast onset floods and landslides to slow onset events such as salinisation and pollutant mobilisation are expected to intensify, amplifying existing threats and creating new risks to vulnerable populations and

exposed assets and supply chains. Water related hazards will have a cascading effect on food security and agriculture, coastlines, forests and biodiversity, public health and the built environment.

Climate change risk, impact and vulnerability assessment is best conducted at the river basin or local scale in conjunction with operational agencies. Climate models are indicative and should be used judiciously for decision-making at river basin or local scales to avoid potential maladaptation. Process oriented approaches that integrate disaster risks, in conjunction with multi-disciplinary observation, monitoring and early warning, as well as stakeholder engagement is recommended. A step-wise approach will enable the identification of near-term disaster risk reduction and long-term climate change adaptation options, which are prudent and more affordable.

Input from the assessment of literature and review of policies (Scope 1), regional assessment (Scope 2), case studies (Scope 3), multiple elicitation techniques (Scope 4) and strategic consultation with stakeholders (Scope 5) have resulted in the following recommendations:

- Enhancing community engagement and capacity in disaster management
- Empowering people for strengthening adaptive capacity to climate change
- Strengthening technical capacity of operational agencies at the river basin level
- Strengthening governance and partnerships at all levels
- Adopting integrated approaches for climate adaptation and disaster risk reduction
- Strengthening regional linkages on disaster risks, climate change and IWRM
- Implementing evidence-based and risk-informed actions
- Enhancing capability for data driven decision making
- Assimilating knowledge to improve planning and implementation
- Investing in disaster risk management
- Strengthening financial capacity for climate resilience
- Enhancing early warning systems and disaster response
- Developing sustainable infrastructure with cost effective technology
- Enhancing disaster preparedness and recovery
- Enhancing conservation measures as an adaptation option for coastal and marine areas

The recommendations have been transformed into programmes, initiatives and activities for the immediate-term (12th MP) in conjunction with government agencies. Additional recommendations have been identified for the near-term (13^{Tth} MP), medium-term (14th MP) and long-term (15th MP) (**Appendix F** and **G**).

The Roadmap is a living document, to be reviewed and updated where and when necessary throughout the coming years to 2040 by NADMA and KASA in conjunction with the EPU. The Roadmap provides programmes and activities that is going to be incorporated as part of the National Policy on Disaster Risk Reduction anchored by NADMA. The Roadmap also provides inputs for the National Adaptation Action Plan that will be developed by KASA.

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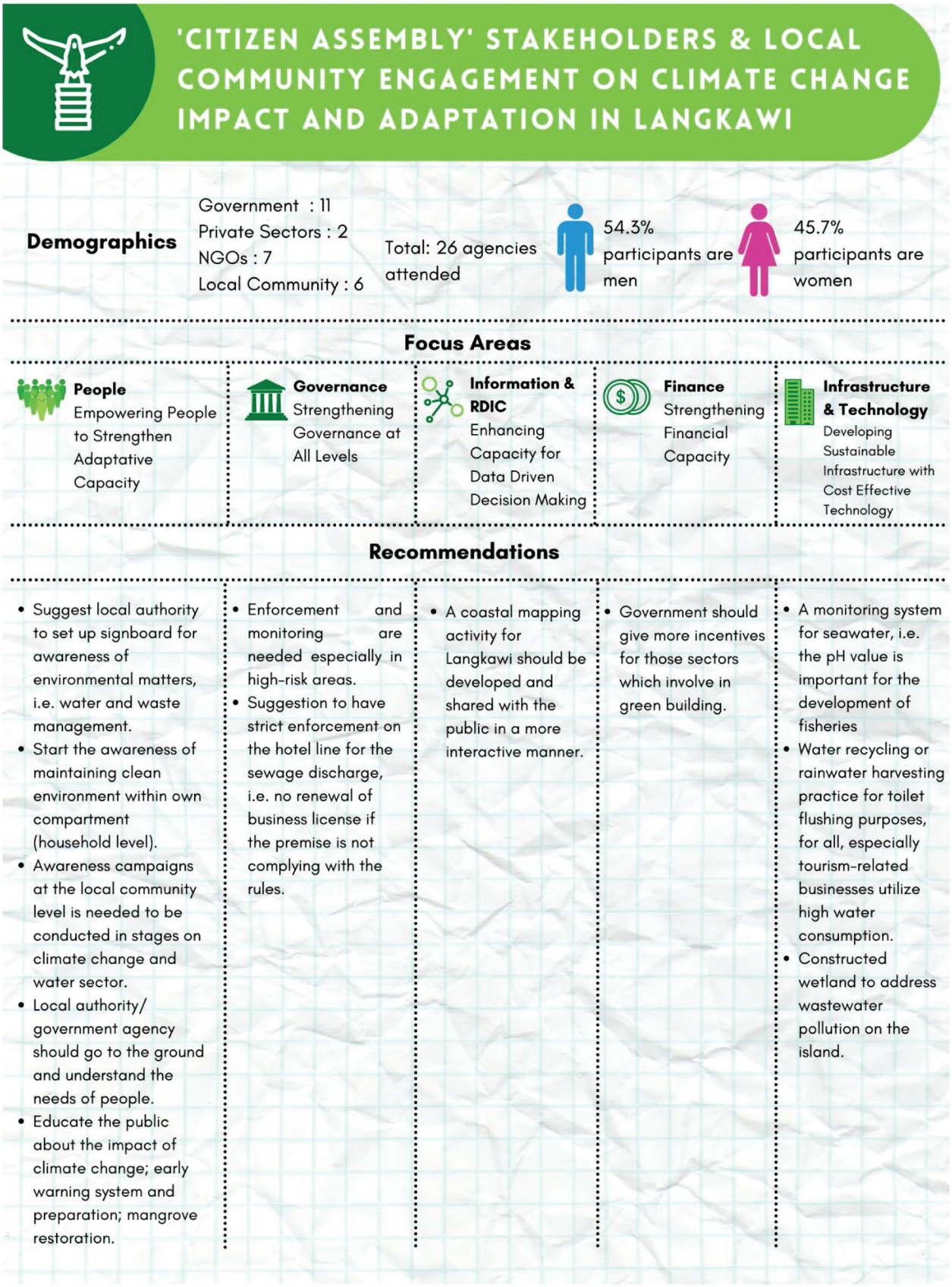
9.0 APPENDICES

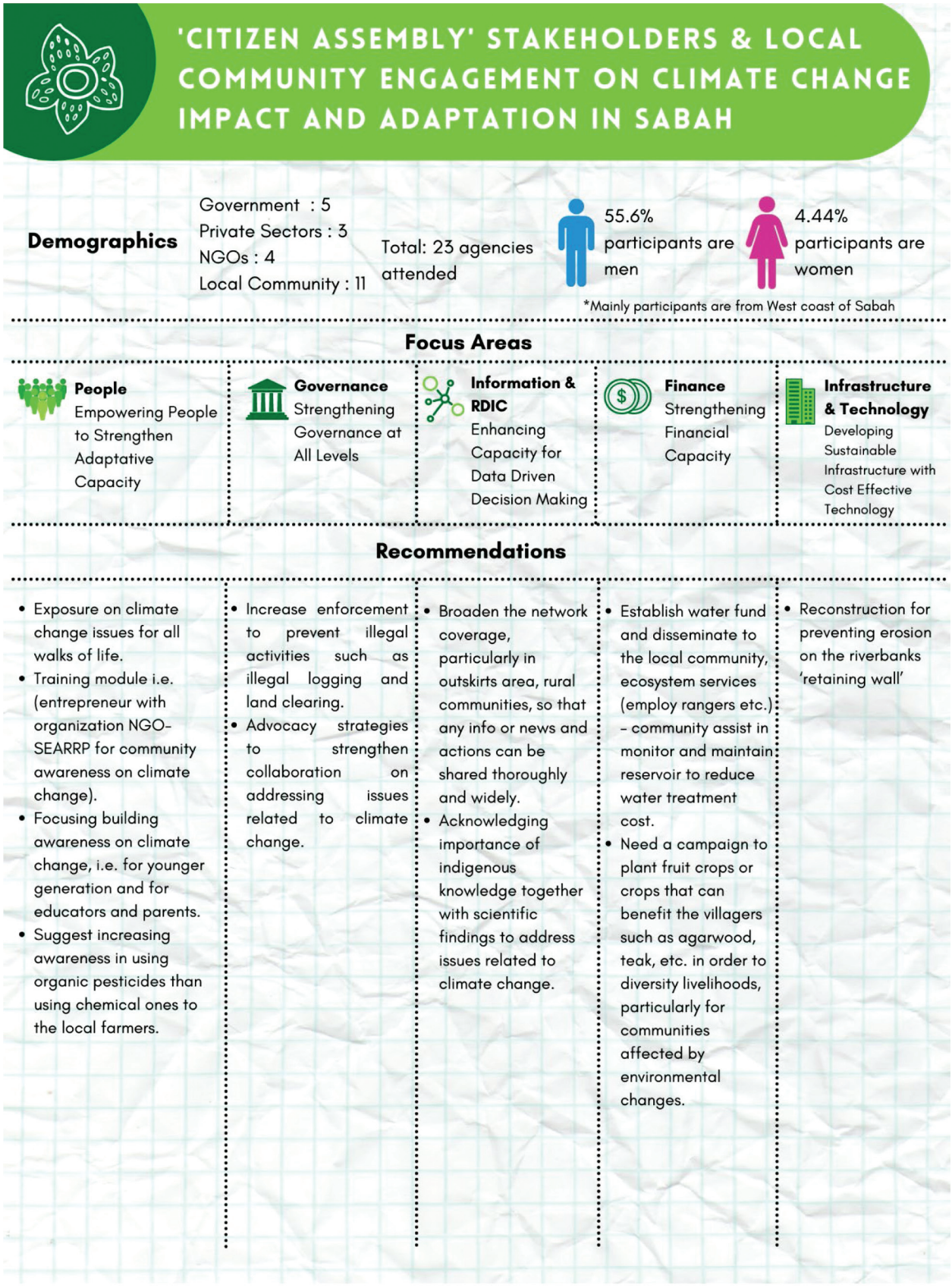
Appendix A List of focus group discussions convened and events covered in 2020-2021.

No.	Focus Group Discussions
1.	Private Sector Engagement with MCG, 28 September 2020
2.	Terrestrial Climate Modelling with experts from UKM, 30 November 2020
3.	Terrestrial Climate Modelling with NAHRIM, 3 December 2020
4.	Groundwater with experts from UKM and ASM Fellows, 1 December 2020
5.	Ocean and Marine Biodiversity, 10 December 2020
6.	Designing the Citizens Assembly with KASA, 16 December 2020
7.	Climate Change, Water and Public Health with MOH and ASM Fellows, 21 December 2020
8.	Terrestrial Climate Modelling with MET Malaysia, 17 March 2021
9.	Low Carbon Cities and Disaster Resilient Cities in Malaysia with MGTC, 22 April 2021
No.	**Events**
1.	Climate Change Conversations: Building Resilience in Cities, Online, 11 September 2020. Lead Organiser: MGTC
2.	Making Cities Resilient by Integrating Nature-Based Solutions into Urban Planning, Online, 30 September 2020. Lead Organiser: UNDRR - Regional Office for Africa
3.	2020 Asia Pacific Science and Technology Conference for Disaster Risk Reduction (eAPSTCDRR), Online, 15 October 2020. Lead Organisers: NADMA and UNDRR
4.	The National Adaptation Plan Consultation Workshop, Online, 14-16 October 2020. Lead Organiser: KASA
5.	IGEM: Financing Climate Action Conference, Online, 20-23 October 2020. Lead Organiser: MGTC
6.	Inclusive Economic Development through Resilience: Opportunities for Doing More and Doing Differently, Online, 29 October 2020. Lead Organiser: ADB
7.	MM-UNICEF Not Risking It: Children and Youth in Climate Adaptation and Disaster Risk Reduction in the Education Sector Virtual Lab, Online, 17 November 2020. Lead Organiser: Mercy Malaysia and UNICEF
8.	SEADPRI Forum 2020: The International Financial Landscape for Climate Change Adaptation Forum, Online, 19 November 2020. Lead Organisers: SEADPRI-UKM & ASM
9.	RISK KAN: A Dismal Perspective on a Boring Topic: An Economist Looks at Insurance, Online, 20 November 2020. Lead Organiser: Risk KAN
10.	Climate Change Conversations: Climate Change and Its Impact on Food Security in Malaysia, Online, 30 November 2020. Lead Organiser: MGTC
11.	Climate Change from Islamic Perspectives: Causes, Impacts and Strategies, Online, 8 December 2020. Lead Organiser: Institute of Islamic Civilisation, UKM
12.	The Malaysia Launch of the 2020 Report of the Lancet Countdown on Health and Climate Change, Online, 17 December 2020. Lead Organiser: Universiti Malaysia Terengganu & MoHE

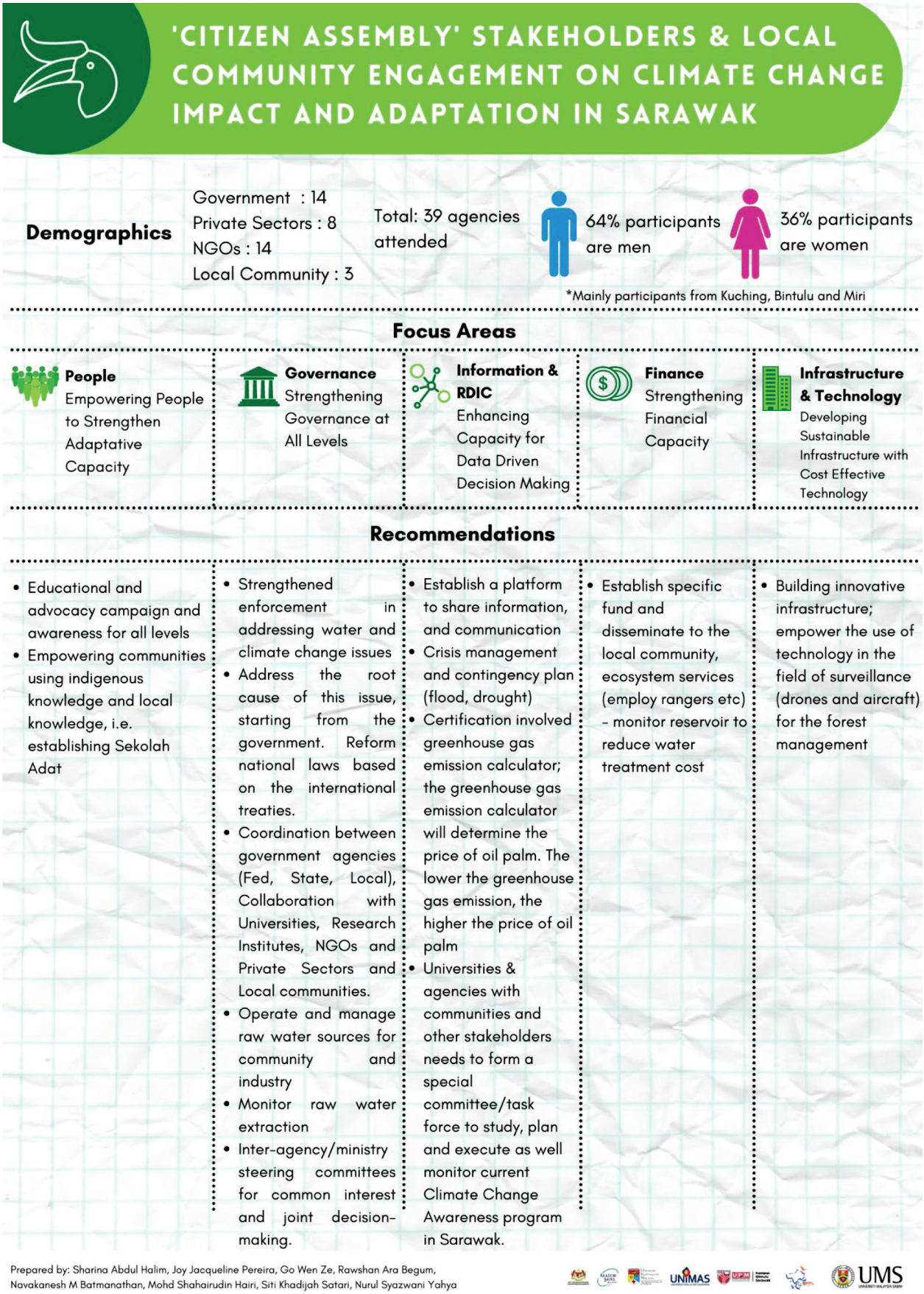
Appendix B Focus areas and recommendations based on findings from Citizen Assembly in Langkawi.



Appendix C Focus areas and recommendations based on findings from Citizen Assembly in Sabah.



Appendix D Focus areas and recommendations based on findings from Citizen Assembly in Sarawak.



Appendix E List of participants in stakeholder consultations.

Date	Key Agency	Participants & Affiliation
14 Dec 2020	Department of Mineral and Geoscience Malaysia (JMG)	**Strategic consultation on Climate Change and Groundwater** 1. Academician Datuk Fateh Chand FASc (ASM) 2. Mr. Loganathan Ponnambalam FASc (ASM) 3. Dato' Yunus Abd Razak (Past Chair, Board of Geologists) 4. Dato' Zakaria Mohamad (Chair, Board of Geologists) 5. Mr. Nizarulikram bin Abdul Rahim (JMG) 6. Mr. Alvyn Clancey Mickey (JMG) 7. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 8. Dr. Nurfashareena Muhamad (UKM) 9. Dr. Go Wen Ze (ASM) 10. Mr. Navakanesh (ASM) 11. 40 members of GSM and IGM
25 Feb 2021	National Disaster Management Agency (NADMA)	**Strategic consultation on Climate Change Adaptation and Disaster Risk Management** 1. Datuk Dr. Aminuddin bin Hassim (NADMA) 2. Dato' Ir. Sabri bin Abdul Mulok (NADMA) 3. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 4. Assoc. Prof. Dr. Arpah Abu Bakar (UUM) 5. Dr. Nurfashareena Muhamad (UKM) 6. Dr. Go Wen Ze (ASM) 7. Mr. Navakanesh (ASM) 8. 38 professionals working on disaster risk management
10 May 2021	Ministry of Health (MOH)	**Consultative Workshop on Mainstreaming Climate Change in Public Health** 1. Pn. Maniza Mahfuz (EPU) 2. Mr. Loganathan Ponnambalam FASc. (ASM) 3. Datuk Dr. Hishamshah bin Mohd Ibrahim (MOH) 4. Dr. Muna Zahira binti Mohd Yusoff (Planning Division, MOH) 5. Dr. Rohana binti Ismail (Family Health Development Division, MOH) 6. Dr. Roslan bin Mohamad (Engineering Service Division, MOH) 7. Mr. Norhafizan bin Daud (Engineering Service Division, MOH) 8. Puan Dalila Farhana Baharudin (Engineering Service Division, MOH) 9. Puan Bariah binti Bakri (Engineering Service Division, MOH) 10. Dr. Norlen bin Mohamed (Disease Control Division, MOH) 11. Dr. Anis Salwa binti Kamarudin (Disease Control Division, MOH) 12. Dr. Rafiza binti Shaharudin (EHRC, IMR) 13. Dr. Rohaida binti Ismail (EHRC, IMR) 14. Dr. Mohamad Iqbal bin Mazeli (EHRC, IMR) 15. Dr. Rohani Mat Bah (KPPK, KPAS Sarawak) 16. Dr. Sharul Rizan bin Ilias (KPPK, KPAS Perlis) 17. Dr. Rosidah binti Omar (KPPK, KPAS Kedah) 18. Dr. Adliah binti Mohamed Soid (KPPK, KPAS Perak) 19. Dr. Khairunnisa Kharimah bt Shafiee (MO, KPAS Perak) 20. Dr. Suriya Kumareswaran (KPPK, KPAS Johor) 21. Dr. Noor Azurah binti Wan Chik (KPPK, KPAS Pahang) 22. Dr. Norazah Ab Aziz (MO, KPAS Pahang) 23. Dr. Valentine Japule Gantul (KPPK, KPAS Sabah) 24. Dr. Rosnelizaide bin Ramely (KPPK, KPAS WPLabuan) 25. Dr. Gunenthira Rao (KPPK, KPAS Pulau Pinang) 26. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 27. Prof. Dr. Mazrura Sahani (UKM) 28. Assoc. Prof. Dr. Rozita Hod (UKM) 29. Dr. Nurfashareena Muhamad (UKM) 30. Dr. Kwan Soo Chen (UKM) 31. Prof. Dr. Hidayatulfathi Othman (UKM)

Appendix E Continued

Date	Key Agency	Participants & Affiliation
		32. Assoc. Prof. Dr. Yanti Rosli (UKM) 33. Assoc. Prof. Dr. Norfazilah Ahmad (UKM) 34. Cik Norhafizah Karim (UKM) 35. Dr. Asif Raihan (UKM) 36. Dr. Go Wen Ze (ASM) 37. Mr. Navakanesh (ASM)
17 May 2021	Department of Mineral and Geoscience	**Malaysia (JMG) Discussion on Groundwater Status for Selangor and Muda River Basins (Preparatory discussion for JMG/KeTSA consultation with ASM on 24 May 2021)** 1. Mr. Loganathan Ponnambalam FASc (ASM) 2. Mr. Alvyn Clancey Mickey (JMG) 3. Mr. Abd Rahim bin Harun (JMG) 4. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 5. Dr. Lim Choun Sian (UKM) 6. Dr. Norsyafina Roslan (UKM) 7. Dr. Go Wen Ze (ASM)
20 May 2021	Disease Control Division, Ministry of Health (MOH)	**Bilateral discussion for WST2040 Draft Roadmap on Climate Change and Public Health** 1. Dr. Norlen Mohamed (MOH) 2. Prof. Dr. Mazrura Sahani (UKM) 3. Assoc. Prof. Dr. Rozita Hod (UKM) 4. Dr. Kwan Soo Chen (UKM) 5. Dr. Go Wen Ze (ASM)
21 May 2021	Engineering Service Division, Ministry of Health (MOH)	**Bilateral discussion for WST2040 Draft Roadmap on Climate Change and Public Health** 1. Mr. Yahaya Saad (MOH) 2. Mr. Norhafizan Daud (MOH) 3. Dr. Roslan Mohamed (MOH) 4. Pn. Bariah Bakri (MOH) 5. Pn. Dalila Farhana (MOH) 6. Prof. Dr. Mazrura Sahani (UKM) 7. Assoc. Prof. Dr. Rozita Hod (UKM) 8. Dr. Kwan Soo Chen (UKM) 9. Dr. Go Wen Ze (ASM)
24 May 2021	Department of Mineral and Geoscience Malaysia (JMG) & Academy of Sciences (ASM)	**Groundwater Roadmap Consultation** 1. Pn. Maniza Mahfuz (EPU) 2. Mr. Abdul Hadi bin Omar (KASA) 3. Pn. Hanis Huzaira binti Abd Hanan (KASA) 4. Ir. Dr. Salmah Zakaria FASc (ASM) 5. Academician Datuk Fateh Chand FASc (ASM) 6. Mr. Loganathan Ponnambalam FASc (ASM) 7. Mr. Zamri bin Ramli (JMG) 8. Mr. Nizarulikram bin Abdul Rahim (JMG) 9. Pn.Hasnida Zabidi (JMG) 10. Pn. Mazatul Akmar Aros (JMG) 11. Mr. Abd Rahim Harun (JMG) 12. Pn. Asminah binti Rajuli (JMG) 13. Mr. Alvyn Clancey Mickey (JMG) 14. Mr. Roslan Rajali (JMG) 15. Mr. Japri Bujang (JMG) 16. Mr. Jaineh Linggi (JMG) 17. Dr. Roslan bin Mohamed (MOH)

Appendix E List of participants in stakeholder consultations.

Date	Key Agency	Participants & Affiliation
		18. Mr. Mohd Aizat bin Aziz (MOH) 19. Ir. Dr. Asmadi bin Ahmad @ Hasan (JPS) 20. Mr. Adnan bin Ismail (MYSA) 21. Mr. Mohd Idham Mansor (MYSA) 22. Mr. Ismail bin Tawnie (NAHRIM) 23. Pn. Noor Adibah binti Mohd Dawi (MAFI) 24. Mr. Mohd Adnan Ahmad Fauzi (MAFI) 25. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 26. Dr. Lim Choun Sian (UKM) 27. Dr. Norsyafina Roslan (UKM) 28. Dr. Go Wen Ze (ASM) 29. Cik Nurul Rahimah Abu Bakar (ASM) 30. Mr. Hareehaaran Mathialagan (ASM)
31 May 2021	Planning Division, Ministry of Health (MOH)	**Bilateral discussion for WST2040 Draft Roadmap on Climate Change and Public Health** Provided feedback via email 1. Dr. Muna Zahira Mohd Yusoff (MOH) 2. Dr. Asma Ahmad Khalid (MOH)
31 May 2021	Academy of Sciences Malaysia (ASM)	**Bilateral discussion for WST2040 Draft Roadmap on Climate Change and Public Health** 1. Prof. Datuk Dr. Lokman Hakim Sulaiman FASc (ASM) 2. Prof. Dr. Mazrura Sahani (UKM) 3. Assoc. Prof. Dr. Rozita Hod (UKM) 4. Dr. Kwan Soo Chen (UKM) 5. Dr. Go Wen Ze (ASM)
1 June 2021	Institute for Medical Research (IMR)	**Bilateral discussion for WST2040 Draft Roadmap on Climate Change and Public Health** 1. Dr. Haji Tahir bin Aris (IMR) 2. Prof. Dr. Mazrura Sahani (UKM) 3. Assoc. Prof. Dr. Rozita Hod (UKM) 4. Dr. Kwan Soo Chen (UKM) 5. Dr. Go Wen Ze (ASM)
10 June 2021	Universiti Kebangsaan Malaysia (UKM)	**Bilateral discussion for WST2040 Draft Roadmap on Climate Change and Public Health** 1. Prof. Dato' Dr. Syed Mohamed Aljunid (UKM) 2. Prof. Dr. Mazrura Sahani (UKM) 3. Assoc. Prof. Dr. Rozita Hod (UKM) 4. Dr. Kwan Soo Chen (UKM) 5. Dr. Go Wen Ze (ASM)
5 July 2021	Ministry of Environment and Water (KASA), Department of Fisheries (DOF), Non-Governmental Organisations (NGOs) and Local Universities	**Multilateral Stakeholder Engagement: Impact of Climate Change on Marine Biodiversity in Malaysia** 1. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 2. Prof. Dato' Dr. Azizan Abu Samah FASc (University of Malaya) 3. Pn. Siti Nooraznie Rahim (KASA) 4. Dr. Cheah Wee (University of Malaya) 5. Prof. Dato' Dr. Nor Aieni Haji Mokhtar (UMT) 6. Prof. Dr. Che Abdul Rahim (UKM) 7. Assoc. Prof. Dr. Lim Po Teen (University of Malaya) 8. Assoc. Prof. Dr. Liew Ju Neng (UKM) 9. Dr. Jilian Ooi Lean Sim (University of Malaya)

Appendix E Continued

Date	Key Agency	Participants & Affiliation
		10. Dr. Zarinah Waheed (UMS) 11. Dr. Lee Jen Nie (UMT) 12. Dr. Lubna Alam (UKM) 13. Dr. Ahmad Aldrie Amir (UKM) 14. Dr. Abe Woo Sau Pinn (USM) 15 Cik Lim Ai Gaik (DOF) 16. Cik Hemalatha Raja Sekaran (DOF) 17. Mr. Affendi Yang Amri (MSMS) 18. Cik Choo Po Leem (WWF) 19. Cik Evelyn Teh (SAM) 20. Mr. Mohamad Zaid Hamzah (MNS) 21. Dr. Go Wen Ze (ASM) 22 Cik Anna Tutsilawati (University of Malaya)
5 July 2021	National Disaster Management Agency (NADMA)	**Bilateral agency meeting with NADMA** 1. Pn. Che Siti Noor Binti Koh Poh Lee @ Che Mamat (NADMA) 2. Pn. Siti Mariam Binti Abu (NADMA) 3. Pn. Hayatul Husna Binti Kamaruddin (NADMA) 4. Prof. Dr. Joy Jacqueline Pereira FASc 5. Dr. Lim Choun Sian 6. Dr. Nurfashareena Muhamad 7. Mr. Mohd Khairul Zain Bin Hj. Ismail 8. Dr. Go Wen Ze 9. Mr. Navakanesh M Batmanathan
15 July 2021	National Disaster Management Agency (NADMA)	**Consultation Workshop with NADMA Officers on DRR Policy** 1. Tuan Jamil Derus Bin Ahmad (Timbalan Ketua Pengarah, NADMA) 2. Dato' Ir. Sabri Abdul Mulok (Pengarah Seksyen Mitigasi, NADMA) 3. Pn. Che Siti Noor Binti Koh Poh Lee @ Che Mamat (Ketua Penolong Pengarah Seksyen Mitigasi, NADMA) 4. Pn. Siti Mariam Binti Abu (Penolong Pengarah Kanan Seksyen Mitigasi, NADMA) 5. Pn. Hayatul Husna Binti Kamaruddin (Penolong Pengarah Seksyen Mitigasi, NADMA) 6. Prof. Dr. Joy Jacqueline Pereira FASc (SEADPRI-UKM) 7. Assoc. Prof. Dr. Arpah Abu Bakar (UUM) 8. Dr. Lim Choun Sian (SEADPRI-UKM) 9. Dr. Nurfashareena Muhamad (SEADPRI-UKM) 10. Mr. Mohd Khairul Zain Bin Hj. Ismail (SEADPRI-UKM) 11. Dr. Tariqur Rahman Bhuiyan (SEADPRI-UKM) 12. Cik Nurul Syazwani Yahaya (SEADPRI-UKM) 13. Cik Husna Shaidin (SEADPRI-UKM) 14. Dr. Go Wen Ze (ASM) 15. Mr. Navakanesh M Batmanathan (ASM) 16. Mr. Ahmad Rajiun bin Abu Bakar (Dasar, NADMA) 17. Mr. Adiratna Wira bin Adnan (Teknikal & Infrastruktur, NADMA) 18. Mr. Mohd Abdul Halim bin Sulaiman (BKP-ICT, NADMA) 19. Pn. Munirah binti Zulkaple (Logistik, NADMA) 20. Supt. Amran bin Dolah (Pelaksanan Operasi, NADMA) 21. Pn. Norbazliah Binti Ibrahim (NDCC, NADMA) 22. Datin Nur Daliza binti Dohat (UKK, NADMA) 23. Mr. Muhammad Fauzie bin Ismail (Pembangunan & Komuniti Sosial, NADMA) 24. Kapt. Mohd Izzuddin (SMART) 25. Pn. Murni binti Mat Amin (Penyelarasan Operasi, NADMA)

Appendix E Continued

Date	Key Agency	Participants & Affiliation
		26. Mr. Mohd Khairi bin Abd. Ghani (Pembangunan & Komuniti Sosial, NADMA) 27. Mejar Shahrul Nizam Jaafar (SMART) 28. Mr. Wan Mohd Fadli bin Ab. Rahman (Dasar, NADMA) 29. Cik Nurul Ain Nabilah binti Azmal (Dasar, NADMA) 30. Mr. Asa'ari bin Zainudin (Teknikal & Infrastruktur, NADMA) 31. Mr. Aiman (BKP-Khidmat Pengurusan, NADMA)
19 July 2021	Department of Mineral and Geoscience Malaysia (JMG)	**CCIA Draft Final Report and Groundwater Roadmap Consultation** 1. Tuan Zamri bin Ramli (JMG) 2. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 3. Pn. Hasnida Zabidi (JMG) 4. Pn. Mazatul Akmar Aros (JMG) 5. Mr. Abd Rahim Harun (JMG) 6. Pn. Asminah binti Rajuli (JMG) 7. Mr. Alvyn Clancey Mickey (JMG) 8. Mr. Ahmad Zamani (JMG) 9. Mr. Wan Neqhaikal Wan Abdul Karim (JMG) 10. Mr. Mohamed Fadzli Rahman (JMG) 11. Mr. Roslan Rajali (JMG) 12. Mr. Japri Bujang (JMG) 13. Mr. Jaineh Linggi (JMG) 14. Dr. Lim Choun Sian (UKM) 15. Dr. Go Wen Ze (ASM) 16. Mr. Navakanesh M Bathmanathan (ASM)
23 July 2021	ASM and Ministry of Energy and Natural Resources (KeTSA)	**Meeting with Dato' Yap and Dr. Elizabeth on CCIA's Draft Final Report (DFR)** 1. Prof. Dr. Joy Jacqueline Pereira FASc (SEADPRI-UKM) 2. Dato' Yap Kok Seng FASc 3. Dr. Elizabeth Philip (KeTSA) 4. Dr. Go Wen Ze (ASM)
12 August 2021	National Disaster Management Agency (NADMA)	**Bengkel Brainstorming Penyediaan Dasar Pengurangan Risiko Bencana Negara (Dasar DRR) (Federal Level)** 1. Tuan Jamil Derus Bin Ahmad (Timbalan Ketua Pengarah, NADMA) 2. Dato' Ir. Sabri Abdul Mulok (Pengarah Seksyen Mitigasi, NADMA) 3. Pn. Che Siti Noor Binti Koh Poh Lee @ Che Mamat (Ketua Penolong Pengarah Seksyen Mitigasi, NADMA) 4. Pn. Siti Mariam Binti Abu (Penolong Pengarah Kanan Seksyen Mitigasi, NADMA) 5. Pn. Hayatul Husna Binti Kamaruddin (Penolong Pengarah Seksyen Mitigasi, NADMA) 6. Prof. Dr. Joy Jacqueline Pereira FASc (SEADPRI-UKM) 7. Dr. Lim Choun Sian (SEADPRI-UKM) 8. Dr. Nurfashareena Muhamad (SEADPRI-UKM) 9. Mr. Mohd Khairul Zain Bin Hj. Ismail (SEADPRI-UKM) 10. Cik Nurul Syazwani Yahaya (SEADPRI-UKM) 11. Dr. Go Wen Ze (ASM) 12. Mr. Navakanesh M Batmanathan (ASM) 13. Pn. Siti Khadijah Satari (SEADPRI-UKM) 14. Mr. Mohd Khairi bin Abd Ghani (NADMA) 15. Pn. Munirah binti Zulkaple (NADMA) 16. Dr. Adiratna Wira bin Adnan (NADMA) 17. Pn. Murni binti Mat Amin (NADMA) 18. Mr. Asaari bin Zainuddin (NADMA)

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Date	Key Agency	Participants & Affiliation
		19. More than 80 representatives from other agencies, i.e: MOE, MOH, JPS, APAM, MGTC, EPU, KASA, NAHRIM, MET Malaysia, JMG, MITI, PLANMalaysia, KPKT, JBPM, SMART, JUPEM, JKP, KeTSA, MOSTI, JKR, RELA, KPDNHEP, DOSH, KPT, Jabatan Kebajikan Masyarakat, Kementerian Dalam Negeri, Kementerian Pertahanan Malaysia, Kementerian Sumber Manusia, Kementerian Luar Negeri dan Tenaga Nasional Berhad.
16 and 19 August 2021	Ministry of Environment and Water (KASA)	**Preparatory Discussion on Stakeholder Engagement** 1. Mr. Ahmad Farid bin Mohamed (KASA) 2. Pn. Siti Nooraznie Rahim (KASA) 3. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 4. Pn. Nor Hidayah Mohammad (KASA) 5. Cik Ezza Sabrina Azmi (KASA) 6. Dr. Go Wen Ze (ASM)
20 August 2021	Malaysian Green Technology And Climate Change Centre (MGTC)	**Follow-up meeting on Low Carbon Cities and Disaster Resilient Cities in Malaysia** 1. Dr. Gary Theseira (MGTC) 2. Mr. Wan Faizal Mohd Anwar (MGTC) 3. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 4. Pn. Komathi Mariyappan (MGTC) 5. Pn. Norhasliza (MGTC) 6. Mr. Raja Aiman (MGTC) 7. Pn. Kiranjeet Kaur (MGTC) 8. Cik Aimi Ayuni Mohamad Sapia (MGTC) 9. Dr. Go Wen Ze (ASM)
24 August 2021	Ministry of Environment and Water (KASA)	**Bengkel Penetapan Perancangan Bagi Tindakan Adaptasi Perubahan Iklim Bagi RMK12 hingga RMK15** 1. Mr. Ahmad Farid bin Mohammed (KASA) 2. Pn. Siti Nooraznie Rahim (KASA) 3. Ir. Dr. Salmah Zakaria FASc (ASM) 4. Prof. Dr. Joy Jacqueline Pereira FASc (UKM/ASM) 5. Mr. Loganathan Ponnambalam FASc (ASM) 6. Datuk Ir. Mohd Adnan Mohd Nor FASc (ASM) 7. Datuk Ir. Abdul Kadir Mohd Din FASc (ASM) 8. Prof. Dr. Mahendhiran Nair FASc (ASM) 9. Pn. Nor Hidayah Mohammad (KASA) 10. Cik Ezza Sabrina Azmi (KASA) 11. Mr. Ahmad Farhan (KASA) 12. Dr. Lim Choun Sian (UKM) 13. Dr. Nurfashareena Muhamad (UKM) 14. Dr. Go Wen Ze (ASM) 15. Mr. Navakanesh M. Bathmanathan (ASM) 16. Mr. Mohd Shahairudin Hairi (ASM) 17. Cik Nurul Rahimah Abu Bakar (ASM) 18. Mr. Hareehaaran Mathialagan (ASM) 19. Mr. Ahmad Ashrin Abdul Jalil (ASM) 20. Cik Siti Nurhayati Kamaruddin (ASM) 21. 80 representatives from other agencies, i.e: JPS, RECODA, NAHRIM, CIDB, FRIM, IRDA, DBKL, LGM, JKR, MOE, MPIC, MOH, MPOB, MOSTI, MPB, JMG, JKM, EPU, SEDA, MOTAC, MGTC, KeTSA, KPLB, ECERDC, KPKT, KKR, MOT, MOHE, JAKOA, MARDI, DOF, MYSA, NCER, MIGHT, MET Malaysia, Malaysian Cocoa Board and Jabatan Laut Malaysia.

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Date	Key Agency	Participants & Affiliation
1 September 2021	National Disaster Management Agency (NADMA)	**Bengkel Penyediaan Dasar Pengurangan Risiko Bencana Negara (Dasar DRR) (State Level)** 1. Tuan Jamil Derus Bin Ahmad (Timbalan Ketua Pengarah, NADMA) 2. Dato' Ir. Sabri Abdul Mulok (Pengarah Seksyen Mitigasi, NADMA) 3. Pn. Che Siti Noor Binti Koh Poh Lee @ Che Mamat (Ketua Penolong Pengarah Seksyen Mitigasi, NADMA) 4. Pn. Siti Mariam Binti Abu (Penolong Pengarah Kanan Seksyen Mitigasi, NADMA) 5. Mr. Ahmad Rajiun bin Abu Bakar (NADMA) 6. Cik Nurul Ain Nabilah binti Azmal (Dasar, NADMA) 7. Prof. Dr. Joy Jacqueline Pereira FASc (SEADPRI-UKM) 8. Dr. Lim Choun Sian (SEADPRI-UKM) 9. Mr. Mohd Khairul Zain Bin Hj. Ismail (SEADPRI-UKM) 10. Pn. Siti Khadijah Satari (SEADPRI-UKM) 11. Cik Nurul Syazwani Yahaya (SEADPRI-UKM) 12. Cik Husna Aini Binti Shaidin (SEADPRI-UKM) 13. Dr. Go Wen Ze (ASM) 14. Mr. Navakanesh M Batmanathan (ASM) 15. Mr. Sandy bin Muhammad Affandi (ECERDC) 16. Pn. Ernnie Syafika binti Omar (SUK Perlis) 17. Pn. Nurul Intan Suraya binti Aminuddin (SUK Pahang) 18. Pn. Shahrinaz Maamor (IRDA) 19. Mr. Abdul Khaliq bin Abdul Hamid (NCIA) 20. Mr. Akmal Farid Rizal bin Noordin (SUK Negeri Sembilan) 21. Mr. Mohd Roshdi Ismail (Kelantan) 22. Mr. Mohd. Firdaus bin Abdul Halim (NCIA) 23. TPr. Saifuddin bin Abdul Karim (Jabatan Ketua Menteri Melaka) 24. Mr. Faisal Rizal bin Hj Mohmmad (BPEN Kedah) 25. Mr. Mohd Azmi Mustafa (SUK Terengganu) 26. Lt Kol (PA) Kamarulsyah bin Muslim (APM Johor) 27. Mr. Mohamad Zahri bin Samingon (SUK Selangor) 28. Mr. Rasis bin Rustam (SUK Johor) 29. Mr. Muhamad Shah Osmin Shah (SUK Selangor) 30. Mr. Noor Azam bin Johari (APM Perak) 31. Mr. Wan Fahazil bin Wan Mohamad Jaffar (UPEN Kelantan) 32. Datu IK Pahon Joyik (Jabatan Ketua Menteri Sarawak) 33. Mr. Mohd Ikram Rahimi (Selangor) 34. Mr. Mohamad Zahri Bin Samingon (TSUK Selangor) 35. Mr. Johan (UP JKM) 36. Pn. Raihani binti Che Mamat (JKT) 37. BKP SUK Melaka
10 September 2021	Malaysian Meteorological Department (MET Malaysia) and National Water Research Institute of Malaysia (NAHRIM) and Local Universities	**Strategic Consultation Workshop: The State of Knowledge on Climate Modelling** 1. Prof. Joy Jacqueline Pereira FASc (UKM) 2. Dr. Sheeba Nettukandy Chenoli (University of Malaya) 3. Dr. Mohd Fadzil Firdzaus Mohd Nor (University of Malaya) 4. Dr. Go Wen Ze (ASM) 5. Mr. Navakanesh M. Batmanathan (ASM) 6. Puan Siti Khadijah (SEADPRI-UKM) 7. Emeritus Prof. Johnny C. L. Chan (City University of Hong Kong) 8. Prof. Dato' Azizan Abu Samah (University of Malaya) 9. Assoc. Prof. Dr. Liew Ju Neng (UKM) 10. Dr. Tan Mou Leong (USM) 11. Dr. Elizabeth Philip (KeTSA)

Appendix E Continued

Date	Key Agency	Participants & Affiliation
		12. Dato' Yap Kok Seng (ASM fellow) 13. Mr. Muhammad Firdaus Ammar Abdullah (MET Malaysia) 14. Mr. Hamray Muhammad Yazit (MET Malaysia) 15. Dr. Ahmad Fairudz Jamaluddin (MET Malaysia) 16. Mr. Ambun Dinding (MET Malaysia) 17. Ir. Azman Mat Jusoh (NAHRIM) 18. Mr. Noor Hisham Ab Ghani (NAHRIM) 19. Dr. Tariqur Rahman Bhuiyan (UKM) 20. Dr. Md Azizul Bari (UKM)
17 September 2021	Department of Mineral and Geoscience Malaysia (JMG)	**Discussion on Groundwater Costing and WST2040 Roadmap** 1. Mr. Loganathan Ponnambalam FASc (ASM) 2. Mr. Abd Rahim Harun (JMG) 3. Pn. Asminah binti Rajuli (JMG) 4. Mr. Alvyn Clancey Mickey (JMG) 5. Mr. Ahmad Zamani (JMG) 6. Mr. Mohamed Fadzli Rahman (JMG) 7. Mr. Roslan Rajali (JMG) 8. Mr. Japri Bujang (JMG) 9. Mr. Jaineh Linggi (JMG) 10. Dr. Ferdaus Ahmad (JMG) 11. Dr. Norsyafina Roslan (UKM) 12. Dr. Lim Choun Sian (UKM) 13. Dr. Go Wen Ze (ASM) 14. Mr. Navakanesh M Bathmanathan (ASM)
22 September 2021	Federal Department of Town & Country Planning (PLAN Malaysia)	**Bilateral discussion with PLANMalaysia for WST2040 Roadmap** 1. Prof. Joy Jacqueline Pereira FASc (UKM) 2. Datin Paduka Dr. Halimaton Saadiah Hashim (UKM) 3. TPr. Dr. Chee Ping Ngang (PLANMalaysia) 4. Pn. Nor Zaliza binti Mohd Puzi (PLANMalaysia) 5. Dr. Go Wen Ze (ASM)
23 September 2021	Ministry of Environment and Water (KASA), Department of Irrigation and Drainage (JPS) and NAHRIM	**Bilateral discussion with JPS and NAHRIM for WST2040 Roadmap** 1. Mr. Ahmad Farid bin Mohammed (KASA) 2. Prof. Dr. Joy Jacqueline Pereira FASc (UKM) 3. Pn. Nor Hidayah Mohammad (KASA) 4. Dr. Go Wen Ze (ASM) 5. Ir. Dr. Asmadi bin Ahmad @ Hasan (JPS) 6. Mr. Wan Marhafidz Shah bin Wan Mohd. Omar (JPS) 7. Mr. Mohammad Hakim bin Hasnul (JPS) 8. Ir. Azman Mat Jusoh (NAHRIM) 9. Ts. Saiful Bahri Hamzah (NAHRIM) 10. Mr. Noor Hisham Ab Ghani (NAHRIM) 11. Dunstan Anthony Pereira (NAHRIM)

Appendix F WST2040 Strategy Plan and Implementation Road Map

Focus Area	WST2040 Strategy Plan and Implementation Road Map 12MP/13MP/14MP/15MP									
	Strategy	**Programmes/ Initiatives**	**Activities**	**Hierarchical Level**	**Lead Authority/ Collaborating Partners**	**Implementing Authority**	**Current Status**	**Target Completion**	**Remarks**	**Targets/KPIs**
People	**Enhancing Community Engagement and Capacity in Disaster Management**	Community-based activities including drills to engage stakeholders in disaster-prone areas across all phases of disaster management.	Plan and implement community-based activities including drills with stakeholders, to engage private sector, civil society organisations, youth, women and vulnerable groups in disaster-prone areas to undertake disaster risk management, preparedness, response, recovery and building back better efforts.	National & Local Levels	NADMA	KPM/KPLB/ KPKT/KPN/ KWP/ APM/ MET Malaysia	New	12th MP and beyond	Estimation with NADMA as the coordinator	Number of activities including drills conducted.
		Capacity building for disaster managers in local authorities and operational agencies for area-specific risk and simulation exercises with multiple partners.	Hands-on technical training for local authorities and other operational agencies in area-specific risk types to develop specialised prevention, preparation and response programmes, including counselling services for post-disaster trauma and simulation exercises.	National & Local Levels	NADMA	NADMA/ KPKT /State governments	New	12th MP and beyond	Estimation of NADMA as coordinator	Number of officers trained.
	Empowering People for Strengthening Adaptive Capacity to Climate Change	Awareness training and community-based adaptation efforts to engage local communities in vulnerable areas to build climate resilience.	Conduct awareness training and community-based adaptation efforts to build climate resilience, including understanding of the climate change, water, food and health nexus and engage local communities in vulnerable areas.	National	KASA	NAHRIM/ IMR/MET Malaysia/MOH /MARDI/ State Governments etc.	New	12th MP and beyond	CEPA and information dissemination	Number of CEPA activities conducted.
		Technical capacity building across relevant sectoral Ministries and agencies at all levels for adaptation planning, implementation and reporting.	Conduct technical capacity building across relevant sectoral Ministries and agencies for adaptation planning, implementation and reporting at all levels, including handling of gender issues, vulnerable groups and international negotiation.	National	KASA	NAHRIM/IMR/ MET Malaysia/ MARDI/State Governments etc.	New	12th MP and beyond	National & Local Levels	Number of officers trained.
			Conduct attachment programme (internal and external), development course for implement officer and staff, create Subject Matter Expert (SME) and promote awareness to fishers and farmers in workshop, consultation session; and efficient coordination between external organisation to provide better information dissemination system to the vulnerable group.	National	MAFI/KASA	DOF/LKIM/ NEKMAT/PNK /NGOs	FRI Strategic Plan 2021-2030	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.	4 Experts in CCA; 100 fishers and farmers in workshops each year; Free mobile data to fishers and farmers.

			Interact with and educate the community regarding port operations and environmental programmes and conduct campaigns for the implementation of electricity saving and energy efficient initiatives.	Authority & District Level/ Internal	MOT/KASA	Port Authority & Terminals/ LPKTN/KPC/ all port users	On-going activities	Continuous implementation	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Port Klang Authority (PKA) & Kuantan Port Authority (KPA)	
		Competency training and certification for environmental professionals with knowledge of climate and disaster risks.	Provide a unique training course that focuses on hands-on approach in scheduled waste management.	Institution	KASA	EiMAS	New	12th MP and beyond	2025-Centre Of Environmental Technology PSIS will be offering consulting work for the community and industrial. A Certificate of Competency will be awarded to participants who successfully complete the course, passes the examination and submits a field training report and attend professional interview at EiMAS.	-
			Provide a training course to train EO for EIA project with land disturbing activities, construction and operation of the entire project to become a competent, skilled and trained professional in environmental management and pollution control.	Institution	KASA	EiMAS	New	12th MP and beyond	2025-Centre Of Environmental Technology PSIS will be offering consulting work for the community and industrial. Certified Professional Environmental Officer in EIA Project Development and Operation (CePEOEIA)	-
			Provide Certificate of Competency in effluent management to participants who successfully complete the course, passes the examination and submits a field training report and attending professional interview at EiMAS.	Institution	KASA	EiMAS	New	12th MP and beyond	2025-Centre Of Environmental Technology PSIS will be offering consulting work for the community and industrial. Certified Environmental Professional in The Operation of Industrial Effluent Treatment Systems (Biological Processes – Activated Sludge Process)	-

			Set forth the criteria of competence for accreditation of testing / calibration performed by a laboratory or an organisation that carries out testing and/or calibration at or from a permanent location; at or from a temporary facility; or in or from a mobile facility.	Institution	KASA	MITI/SAMM	New	12th MP and beyond	Certification of Environmental Testing Laboratory under Laboratory Accreditation Scheme of Malaysia (SAMM) MS ISO/IEC 17025	Achieving and sustaining accreditation of MS ISO/IEC 17025 by 2022.
		Community-based adaptation for the water sector in river basins to promote engagement of multiple stakeholders.	Provide training based on training module of Advocacy Awareness and Capacity Building.	Federal	KASA	JPS	New	12th MP and beyond	Currently awareness programmes fund in JPS is under project cost basis, no dedicated allocation is given. Based on Training Module of Advocacy Awareness and Capacity Building (AACB) Task Force	Number of river basin.
		Technical capacity building for health professionals on management of climate sensitive diseases and outbreaks during disasters.	Climate change and health vulnerability and adaptation assessment (VNA).	National	MOH/KASA	MOH (KPAS, IMR)/NAHRIM/ MET Malaysia/ NGO	New	12th MP	Attachment at Climate Change Centre in Germany or equivalent centre in other countries monitoring mechanisms development- can be part of EHIS costs to manage the climate sensitive diseases	
			Climate resilient health care facilities.	National	MOH/KASA	MOH	New	12th MP	In-house training (SHD & DHD) location and relocation of healthcare facilities away from disaster areas (Bahagian Perancang)	
			Health co benefit of climate change mitigation.	National	MOH/KASA	MOH (KPAS, IMR)/NGO/ Academia	New	13th MP	In healthcare wastes incineration, energy, patient transportations to hospitals	
			Provide training for preparedness, table top training, big data analysis and management starting at university level and strengthen the role of health education officers for risk communication, health promotion to community and media (FB).	National	MOH/KASA	MOH/Health Promotion Institute, NIH	New	12th MP and beyond	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.	
		Capacity building of trainers and teachers on climate change and sustainable water resources management.	Train and retrain teachers on activities that are related to water resource management.	National	KASA	MOE/IPGM/ BPG/KPM	New	12th MP and beyond		211,570 teachers

			Plan and conduct structured teacher professional development for in-service teachers based on the guidebook or teaching module on water sustainability by ASM. (BPG)	National	KASA	MOE/IPGM/ BPG/KPM	New	12th MP and beyond	i. Streamline land use planning with water resource management (IWRM), Integrated River Basin Management (IRBM) and other environmentally sensitive areas (ESAs), integrating climate change mitigation/adaptation and disaster risk reduction;	
			Train the trainers and teachers using various approaches of training such as face to face, online, and hybrid. (IPGM)	National	KASA	MOE/IPGM/ BPG/KPM	New	12th MP and beyond	ii. Climate Science and its relationship with land use planning (impacts and causes);	140 Trainers
			Develop inquiry-based climate change pedagogical resources for formal and non-formal settings, including resources for teachers' professional development.	National	KASA	MOE/MGTC/ ASM/ISTIC and Office for Climate Education/ UNESCO/ BPPDP (Pusat STEM Negara)/IPGM /BSKK	New	12th MP and beyond	iii. Science-based decision making based on forecast climate change scenarios (e.g. temperature rise, sea level rise); Example: http://www. canadiangeogr aphic. com/educational_pr oducts/activities/ climate_c hange_ lesson_plans/EN/L iving_World%20_ Activitie s/Climate-Change-Lesson-Plan_Living_World_ Teach ers_Guide.pdf	
			Train the trainers and teachers using various approaches of training such as face to face, online, and hybrid. (IPGM)	National	KASA	MOE/MGTC/ ASM/ISTIC and Office for Climate Education/ UNESCOBPP DP (Pusat STEM Negara)/IPGM /BSKK	New	12th MP and beyond	iv. Science-based decision-making based on development scenarios; and	211,570 teachers 140 Trainers

			Conduct a professional development programme to familiarise teachers with climate science, active pedagogy and project design.	National	KASA	MOE/ASM/ ISTIC and Office for Climate Education/ UNESCOIPG M and BPG/KPM	New	12th MP and beyond	v. Regulatory framework for IWRM, IRBM and ESAs through effective land use planning. Structured teacher professional development for in-service teachers will be based on the guidebook or teaching module on water sustainability by ASM (BPG). Train the trainers and teachers using various approaches of training such as face to face, online, and hybrid. (IPGM)	211,570 teachers 140 Trainers
			Develop a climate literacy assessment instrument.	National	KASA	MOHE/MOE	New	12th MP	The instrument is developed during 12 MP.	
			Establish a single, searchable, user-friendly online resource for finding water- and climate-related education programmes and resources and funding opportunities (using a new or enhanced platform).	National	KASA	KASA/MOE	New	12th MP	The online platform is developed during 12 MP.	
			Expand digital platforms/tools for teaching and learning and develop simulation-based games, mobile platforms, virtual environments, and augmented reality tools to heighten curiosity and increase learner engagement.	National	KASA	MOSTI/MOE/ ASM	New	12th MP	The digital platforms/ tools are developed during 12 MP.	
			Promote awareness among school children by organising webinars on the importance of water and the impacts of climate on water resources.	State and National	KASA	MOE/BPSH/ KPM	New	12th MP and beyond	Yearly event. Student present in the webinar. Token of appreciation to be given to the all participants at national and state level. Estimated budget (yearly): i. National level- RM16K ii. State Level- RM38.4K	4 series of webinar at national level and one webinar at state level. Dan sekurang-kurangnya 5-10 % peningkatan murid SM dan SR menonton webinar setiap tahun mulai tahun 2022.

			Educate present and future generations about climate change by providing tools to help students learn science and geography more fun and effectively.	National	KASA	MOE/BPK/ KPM	New	12th MP	Involving 2,445 secondary schools	
			Develop blueprint and GRI report system to enhance generic skill, knowledge and implement sustainable lifestyle that focus on SDGs and blueprint's field of focus.	Polytechnic and Community Colleges	KASA	MOHE/MOHR/ Department Skill Development (JPK)/SustNet International Green Training Centre (IGTC)/Polytechnic and Community Colleges/	On-going activities	13th MP	Blueprint POLYGreen Politeknik Malaysia (BPPM) and Blueprint Smartgreen PolyCC (BSGPC)	1 blueprint.
			Develop Green Curriculum for all Malaysian polytechnic and community colleges programmes to produce graduates who are recognised by industry (green collar job).	Department of Curriculum (BK), JPPKK, Polytechnic and Community Colleges	KASA	MOHE/MOHR/ Department Skill Development (JPK)/SustNet International Green Training Centre (IGTC)/Polytechnic and Community Colleges	On-going activities	12th MP and beyond	Blueprint POLYGreen Politeknik Malaysia (BPPM) and Blueprint Smartgreen PolyCC (BSGPC)	100 % polytechnic community colleges curriculum embedded green element.
			Organise or offer courses/ programmes that emphasise on skills in green technology and sustainability to produce 4IR TVET graduates responsive to industrial needs and SDGs.	Polytechnic and Community Colleges	KASA	MOHE/MOHR/ Department Skill Development (JPK)/SustNet International Green Training Centre (IGTC)/ Polytechnic and Community Colleges	On-going activities	12th MP and beyond	Sustainability Development Skills Programme for Polytechnics and Community Colleges towards Green TVET	1- Graduate Employability. 2- Employer Satisfaction Index.
			Develop teacher professional development workshop modules and pedagogical activities (for formal	National	KASA	MOSTI/MOE/ ASM/Humid Tropics Center	New	12th MP	The content for the module on water sustainability is developed	

			and non-formal settings) on water sustainability and climate change adaptation.			(HTC-KL)			during 12 MP. Based on Training Module for Academia under AACB Example: https://www.mrcmekong.o rg/assets/Publications/Ma nuals-and-Toolkits/BDP-Training-Manual-final-2011-update260112.pdf https://serc.carleton.edu/t eachearth/activities/23636 3.html	
			Compile local and international case studies on the best practices of river/water management and climate change adaption.	National	KASA	MOSTI/MOE/ ASM/Humid Tropics Center (HTC - KL)	New	12th MP	The case studies on the best practices of river/water management are compiled during 12 MP. Based on Training Module for Academia under AACB	
			Education on water and climate change: Promote digital literacy through reading digital materials on water and climate change (one of the activity under school resources centre).	National	KASA	MOE/BSTP/ KPM	New	12th MP and beyond	All schools (10,220) in Malaysia Based on Training Module for Academia under AACB	10220 schools.
			Arrange education programmes that involve learners using open government data related to water and climate change in data-driven decision making.	National	KASA	MOE/BSKK/ KPM	New	12th MP and beyond	50% of the total schools (16,440) in Malaysia Based on Training Module for Academia under AACB	8,220 schools.
			Offer bachelor courses in Sustainability and Green Technology (PALS1012) and master course in Climate Change in the Tropics.	National	KASA	MOHE/ MOE/ IPGM/ University of Malaya	New	12th MP and beyond	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Kurikulum ini akan diguna pakai mulai ambilan Jun 2022.	Next generation of scientists that are equipped with knowledge on climate change and its impacts.

			Develop educational resources and activities on water and climate change in Digital Educational Learning Initiatives Malaysia (DELIMa) platform.	National	KASA	MOE/BSTP	New	12th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. The online platform is to be developed during 12 MP. Continuous enhancement of educational resources and activities on water and climate change in DELIMa	All schools (10,220) can access the educational resources and activities in DELIMa.
	Strengthening Capacity of Operational Agencies at the River Basin Level	Capacity building for integrating disaster risks and long-term climate hazards through spatial integration.	Train urban planners and supporting staff from the public (federal, state and local levels), private sector (members from the Malaysian Institute of Planners and other related professional bodies such as engineers, landscape architects, architects and surveyors) in spatial integration of DRR and CCA; and conduct attachment programmes (external) through skill share programmes in developed countries.	Federal-State-Local Authority-Private Sectors	NADMA	PLANMalaysia /NADMA/11 PLANMalaysia State Offices/ Select ed Local Authorities/ Malaysian Institute of Planners (MIP)/UK Government (through UK Pact)	New	12th MP and beyond	Training for trainers in 2022 and 2023. Those who have been trained in 2022 and 2023 will be the trainers for the following batches.	Annual training of 10 urban planners from PLANMalaysia; 14 urban planners from PLANMalaysia@ St ate (including Sabah & Sarawak); 10 urban planners form local authorities; 10 urban planners from Malaysian Institute of Planners; and 10 Institute of engineers, institute of landscape architects, institute of surveyors.
Governance	**Strengthening Governance and Partnerships at All Levels**	National policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR.	Develop a national policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR to strengthen institutional arrangements.	National & Local Levels	NADMA	NADMA/ KPKT /State governments	New	12th MP and beyond	2023: Proposal to update strategies/ plans for climate extreme events (1mil) 13MP: Scaling up strategies to cover all states. 14MP: Formulation of legislation, revision of national and local strategies. 15MP: Focus on man-made and Natech	Number of policy/plans/ legislati ons.

		Human capital for state and local levels, to further improve the efficiency of disaster response measures.	Strengthen disaster risk management through establishment of NADMA office at state level.	National & Local Levels	NADMA	NADMA/ JPA/ State governments	New	13MP and beyond	13MP: Establishment of state operations (subject to restructuring) 14MP: Upgrading of infrastructure. 15MP: Operations and management.	Number of offices in every state.
		Adaptation actions, implementation, monitoring and reporting of climate change adaptation progress at all levels.	National adaptation action plan for reporting and implementation and monitoring of climate change adaptation at all levels.	National	KASA	NADMA/ KPKT /State governments	New	12 MP and beyond	KASA as the coordinating agency	NAP and Implementation Plan.
		CCA centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for informed decision-making at all levels.	Establishment of CCA centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for better coordination, effective implementation and informed decision-making at all levels.	National	KASA	NAHRIM/ IMR/MET Malaysia/MOH /MARDI/ State Governments etc.	New	12 MP and beyond	2024: feasibility study	1 coordinating centre with staff.
	Adopting Integrated Approaches for Climate Change Adaptation and Disaster Risk Reduction	Land use and spatial planning governance at all levels for integrating climate adaptation and disaster risks.	Study the roles of land use and spatial planning governance in Peninsular Malaysia [National Physical Planning Council (Federal Level), Regional Planning Committee (Regional Level), State Planning Committee (State Level), OSC Committee Meetings (local authority level)]. The study includes proposing a mechanism to plan, coordinate and control development based on the river basin. Study on innovative financing mechanisms to encourage and incentivise states and local authorities to preserve water resources areas and adopt sustainable land use planning by mainstreaming IWRM, IRBM, ESAs, climate change mitigation/adaptation and disaster risk reduction.	Federal-regional-state-local authority	NADMA	PLANMalaysia /11 PLANMalaysia State Offices/ Select ed Local Authorities	New	12 MP	The levels include the National Physical Planning Council (Federal Level), Regional Planning Committee (Regional Level), State Planning Committee (State Level), OSC Committee Meetings (local authority level)]. 1. To expand the role and responsibility of every level of land use and spatial planning governance in Peninsular Malaysia to integrate water resource management (IWRM), Integrated River Basin Management (IRBM), and Environmentally Sensitive Areas (ESAs) into climate change mitigation/adaptation and disaster risk reduction. 2. Coordination of inter-state and inter-sectoral policies, planning, implementation and monitoring of development activities. 3. Land Use Planning and management of IWRM, IRBM and ESAs.	1 study on governing and financing mechanism.

		Guidelines for disaster resilient cities to address climate extremes and integration of low carbon cities, sponge city and smart city for nation-wide adoption.	Formulate disaster resilience guidelines, preparedness plans, building codes and retrofitting approaches for critical buildings and infrastructure in cities, to integrate low carbon city, sponge city, smart city, etc. for nation-wide adoption in cities and townships.	National & Local Levels	NADMA/KASA/ KPKT	NADMA/ KASA /KPKT/ JKT/ State governments	New	12th MP and beyond	To be jointly implemented with the programme on low carbon and smart cities.	Guidelines, integrated plans; 2 pilots and 5 cities and townships per year.
		Smart partnerships and coordination platforms to strengthen the health, disaster and climate nexus.	Strengthen coordination platform which relates to environment & health; and climate sensitive diseases. (eg. NEHAP).	National	MOH/KASA	NEHAP Secretariat/ All Agencies involved in EH	On-going activities	12th MP and beyond	NEHAP is coordinated by the MOH and has the cooperation of various agencies related to environmental health. However, no specific allocation was channelled for the implementation of NEHAP.	Coordination platform for environmental health.
			Public health standard on drinking water quality-gazette and enforce the Drinking Water Quality Act (DWQA) and regulations.	National	MOH/KASA	MOH/SPAN/ Jabatan Kimia Malaysia	On-going activities	12th MP and beyond	Operating budget There are currently no laws and regulations regarding drinking water quality. The implementation of drinking water monitoring is based on administratively through the cooperation of relevant parties and stakeholders.	DWQA gazetted and enforced.
			Assess the resilience status of healthcare facilities to climate change and disaster risks.	National	MOH/KASA	HQ MOH/SHD/ DHD KPAS, IMR	On-going activities	12th MP and beyond	Healthcare facilities vulnerability and adaptation assessment (VNA) 10% out of total healthcare facilities annually	Number of officers trained.

		Manage climate sensitive diseases including control of vector borne diseases through the Wolbachia program.	National	MOT/KASA	HQ MOH/SHD/ DHD	On-going activities	12th MP	After 2 years of implementation, all localities in Phase 1 have shown reduction in number of Dengue cases. Implementation cost per locality: RM 45,742.13 for capital cost RM 104,638.67 for maintenance cost Total cost: RM 150,380.8 Wolbachia Aedes mosquito operationalisation in 20 localities with high Dengue burden	
			National	MOT/KASA	MOH	New	12th MP and beyond	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.	
		Strengthen steering committee link with technical committee with regular meetings; review on priority area in climate change and health (NEHAP TWG 10) including emerging and re-emerging diseases and develop policy brief on Climate Change and Health (NEHAP TWG 10/TWG 5/NAHRIM; provide leadership training; enhance and integrate disease control and prevention management; promote self-regulation (self-assessment, monitoring) with mitigating actions; and assess healthcare system to enable planning and implementation of adaptive management strategies.							
	Partnerships, coordination platforms and framework for integrating climate and disaster risks.	Implement MyGAP and registration for all farms (small and large) in aquaculture sector; strengthen Fisheries Management Plan, eliminate IUU fishing, establish more MPA and conservation areas, develop more artificial reef, stop overexploitation and further develop high seas fisheries; standardise states' inland fisheries enactments, establish proper and coordinated management of inland water bodies, pollution prevention and public restocking.	National & State	MAFI/KASA	DOF/STATES/ DOE	New	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.	(1) All registered farms implement MyGAP (2) All farms/ cage/hatchery/ systems registered (3) FMP (53) established and updated (4) >90% of IUU eliminated (5) 10% MPA + 10%cons area (6) 50 locations AR developed each year (7) Exploitation rate

										at manageable and sustainable level (8) 20 vessels each year; Langkawi, Penang, Labuan, Semporna ports fully develop with downstream industry (9) Gazettement of standardised enactments (13+1 states) (10) Integrated River Basin Management (11) Maintain current Class and least Class III for all waterbodies. (12) Public restocking for native species of specific waterbodies.
			Collaborate with UPNM in the study of the development of Wave Energy Converter (converting wave kinetic energy to electrical energy); strengthen engagement of stakeholders, public & related OGAs to provide equal weight to economic, social concern and environmental in the decision-making process; develop master plan for port development taking into account climate change adaptation and establish coordination, implementation of facilities that climate resilient.	Internal/ Authority Level	MOT/KASA	LPKTN/KPC/ UPNM/Port Authority & Terminals/ PPC & port operator Through concessionaire with port operator	On-going activities	Continuous implemen-tation	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Kuantan Port Authority (KPA), Port Klang Authority (PKA), and Penang Port Commission (PPC)	Deliver fair decision and commitment towards economic, social and environmental friendly development.
		Comprehensive groundwater governance at all levels to support conjunctive use of surface water and groundwater for implementing IWRM.	Set up a standing committee on groundwater by the National Water Council.	National	KeTSA/KASA	JMG	New	12th MP		
	Partnerships, coordination platforms and framework for integrating climate and disaster risks.	International linkages on disaster management for joint technical programmes and simulation exercises.	Strengthen linkages with ASEAN and other international platforms (UNDRR, etc.) on joint technical programmes, training, simulation exercise, etc.	International/ National	NADMA	KPM/KPT/ KASA/MOSTI/ APM/JBPM/ TNB/KLN/ KPLB/KPKT/ KWP/RELA	New	13th MP and beyond	International and regional programmes organised by Malaysia.	1 international programme per year.

Information & RDIC									
Implementing Evidence-Based and Risk-Informed Actions	Multi-hazard risk management and vulnerability assessment for extreme events and cascading hazards, high-risk and sensitive areas and communities.	Expand multi-hazard risk management and vulnerability assessment for extreme weather events and cascading hazards for prevention, forecasting, monitoring, early warning and control measures according to types of disaster (Flood, Landslide, Storms, Earthquake, Natech etc.).	National	NADMA/MOSTI/ KASA/KeTSA	MET Malaysia/ JPS/JMG/ MYSA/ JKR	On-going activities	12th MP and beyond	12MP: Tsunami risk assessment, NRR for man-made and rapid & slow on-set risk assessments. 13MP: Expansion to local level scale and coverage of more hazards (natural & man-made) for selected pilots. 14MP: Expansion to local level scale and coverage of more hazards (natural & man-made). 15MP: Expansion to local level scale and coverage of more hazards (natural & man-made).		
	Establish a multi-hazard data centre and risk register platform for efficient information sharing and risk communication through use of ICT.	Strengthen one stop environment-related data centre by improving data sharing among various stakeholders, including the private sector and CSOs to support decision-making.	National	NADMA	NDCC	New	12th MP and beyond	12MP: Feasibility and upgrading of NDCC. 13MP: Development of centralised disaster information platform. 14MP: Maintenance and expansion to state level. 15MP: Maintenance and expansion to state level.	
	Streamline land use planning for river basins and administrative boundaries.	Conduct pilot studies to streamline land use planning with IWRM (environmental units), IRBM, ESAs, climate change adaptation and disaster risk reduction.	Federal-Regional-State-Local Authority	NADMA	PLANMalaysia /State Level/Regional Agencies/ Local Authority/ KASA/ NAHRIM/JPS	New	12th MP	i. Conduct pilot studies for 2 River Basins and 1 coastal area. ii. Develop a land use scenario planning model (based on climate change impact eg.1.5°C rise) and develop decision support system for every case study: - 1 Coastal Area (scenario of temperature rise, sea level rise and development trend). - 2 River Basin (scenario of temperature rise, development trend and water consumption). iii. Propose future land use planning based on scenario planning.	i. 2 River Basin Land Use Planning and Management Plan (with a system for scenario building and decision support system); ii. 1 Coastal Land Use Planning and Management Plan (with a system for scenario building and decision support system); iii. Land Use Scenario Planning Model and decision support system able to be replicated to other areas with similar characteristics.

			Mainstream IWRM, IRBM, ESAs, climate change adaptation and disaster risk reduction into administrative development plans (local plan and special area plan) to plan for Climate Resilient Cities and Hinterlands.	Internal/ Authority Level	NADMA	PLANMalaysia /State Level/Regional Agencies/ Local Authority/ KASA/ NAHRIM/JPS/ JMG	New	12th MP and beyond	i. Incorporate findings from River Basin Land Use Planning and Management Plan and Coastal Land Use Planning and Management Plan into 2 local plans and 3 special area plans in: - 1 local plan in an urban setting; - 1 local plan in a rural setting; - 1 special area plan in a coastal area; - 1 special area plan in high-density city; - 1 special area plan for hilly terrain area ii. Develop a land use scenario planning model (based on climate change impact, e.g. 1.5°C rise) and develop analytical tools for rationalising river basin boundary with administration boundary. iii. Mainstream IWRM, IRBM, ESAs, climate change mitigation/ adaptation and disaster risk reduction into spatial plans.	i. 1 local plan in an urban setting (with scenario building and decision support system); ii. 1 local plan in a rural setting (with scenario building and decision support system); iii. 1 special area plan in the coastal area (with scenario building and decision support system); and iv. 1 special area plan in high-density city (with scenario building and decision support system). v. 1 special area plan for hilly terrain area (with scenario building and decision support system).

						iv. Develop decision-making tools based integrating IWRM, IRBM, ESA and climate change mitigation/adaptation and disaster risk reduction. v. Develop planning guidelines as a guide for development control. i. 1 River Basin Land Use Management Plan (2023-2024) - 3 million ii. 1 Coastal Land Use Management Plan (2023-2024) - 3 million iii. 1 River Basin Land Use Management Plan (2024-2025) - 3 million Modelling System to be completed in the 1st 6 months.	Deliver fair decision and commitment towards economic, social and environmental friendly development.
					12th MP and beyond	Expand integrated weather & sea level rise impacts on groundwater aquifers; develop & establish integrated transboundary groundwater management system; Transboundary Aquifer Monitoring (TMA) & Total Maximum Daily Pumping (TMDP); and enhance groundwater station for groundwater quality monitoring & water auditing (water cycle/water balance); monitoring wells with lysimetre instrument.	National Groundwater Monitoring System (NaGMiS) for groundwater hazards.
				New	13th MP and beyond	Integration of DRR & CCA	
			JMG/State Government		JMG	New	
		NADMA/ KeTSA			NADMA/KeTSA		
	National & State				National		
Undertake vulnerability assessment and climate change impacts in water stressed areas, communities & sectors for groundwater.					Conduct groundwater hazards mapping, monitoring to develop early warning system for effective multi-scale disaster response.		
Monitoring and assessment of emerging groundwater hazards to improve groundwater management and disaster preparedness.							

	Enhancing Capability for Data Driven Decision-making	Weather, climate and geophysical information services for water related hazards such as flood, drought and tsunami.	Strengthen the surface meteorological observations networks (maintaining, upgrading & adding).	National	KASA/NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond	Integration of DRR & CCA	
			Strengthen the weather radar and satellite systems (maintaining, upgrading & adding).	National	KASA/NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond	Integration of DRR & CCA Two radar stations for each MP.	
			Empower Meteorological Main Computing System for generating, processing and display of weather forecasting and warning.	National	KASA/NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond	Integration of DRR & CCA Towards implementation of cloud computing technology and fulfil the requirements of green technology in ICT	
			Enhance earthquake and tsunami monitoring and early warning systems.	National	KASA/NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond	Integration of DRR & CCA	
			Strengthen seismic, tsunami siren and tide gauge monitoring networks.	National	KASA/NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond	Integration of DRR & CCA 14MP for upgrading system.	
			Enhance climate database and products (Fire Danger Rating System, Heatwave etc.).	National	KASA/NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond	Integration of DRR & CCA 15th MP for upgrading system. Aims to provide comprehensive outputs in term of meteorological information and services for the use of relevant authorities, general public, media and others.	
			Develop new method of cloud seeding using UAV/ Drone and LIDAR technology.	National	KASA/NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond	Integration of DRR & CCA 12th MP for testing, 13th MP purchasing UAV	
		Climate science and modelling for planning and implementation to support decision-making at the river-basin level.	Develop the Mesoscale Ensemble prediction System (seasonal prediction + climate projection).	National	KASA/NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond	Integration of DRR & CCA Eventual goal to produce a multiscale global model	

		Improve numerical weather modelling product (WRF subkm).	National	KASA /NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond
							Specifically focusing on the tropics to enhance weather and climate services in Malaysia. Eventual goal to produce a semi-hemispheric global model to drive the high-resolution models for weather and climatic scales to have a better understanding on extremes in the tropics for disaster preparedness. Model information will be used by various sectors such as Agriculture (food security), Flood Modelling and Disaster preparedness, Dam and reservoir management, preparation of climate action plan for megacities in Malaysia, Disaster management for weather and climate related extremes for local authorities.
		Improve Climate Change Resilience in Megacity through Mainstreaming Climate Urban Downscaling Projection (urban microclimate modelling).	National	KASA /NADMA	MET Malaysia/ Relevant States	New	13th MP and beyond
							Integration of DRR & CCA Eventual goal to produce a multiscale global model specifically focusing on the tropics to enhance weather and climate services in Malaysia. Eventual goal to produce a semi-hemispheric global model to drive the high-resolution models for weather and climatic scales to have a better understanding on extremes in the tropics for disaster preparedness. Model information will be used by various sectors such

									as Agriculture (food security), Flood Modelling and Disaster preparedness, Dam and reservoir management, preparation of climate action plan for megacities in Malaysia, Disaster management for weather and climate related extremes for local authorities.	
			Atmospheric pollution-related monitoring and modelling; simulate air pollution dispersion employing WRF/ CMAQ modelling platform.	National	KASA /NADMA	MET Malaysia/ Relevant States	New	12th MP and beyond	Integration of DRR & CCA	
			Strengthen the National GHG monitoring station and other atmospheric pollutants (maintaining, upgrading & adding).	National	KASA /NADMA	MET Malaysia/ Relevant States	On-going activities	12th MP and beyond	Integration of DRR & CCA GHG and atmospheric pollutants become major problem especially over megacities. Early warning system for GHG and other atmospheric pollutants is essential.	
			Simulate dynamics and interconnections between three major subsystems of the globe, namely, climate, biosphere, and society with respect to greenhouse gases emissions.	National	KASA /NADMA	MET Malaysia/ Relevant States	New	13th MP and beyond	Integration of DRR & CCA Outputs will include cumulative greenhouse gas emissions, resulting atmospheric concentrations, global warming, sea level rise, agricultural impacts, ecosystem risks, and also costs of policies for emissions reduction or control.	
		Climate change impacts on water resources and supply at the river basin scale.	Expand National Water Balance System (NAWABS) and National Flood Forecasting and Warning system (NaFFWS) to other river basin in Malaysia and enhance existing NAWABS and NaFFWS model with current and future technology related to climate change impact.	Federal	KASA/KeTSA/ MAFI/NADMA	JPS	On-going activities	12th MP and beyond	Integration of DRR & CCA Cost for Model and system development and enhancement.	Number of river basin.

		Smart technology for irrigation systems and crop production.	Implement IoT and sensor technologies in irrigation system application for traditional pepper farm.	National	MPIC/KASA	MPB/DOA	On-going activities	12th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021	IoT technology in pepper farming throughout Malaysia.
			Implement IoT and sensor technologies in production of white pepper berries.	National	MPIC/KASA	MPB/DOA	On-going activities	12th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021	IoT technology in pepper farming throughout Malaysia.
			Develop water footprint for sustainable natural rubber production.	National	MPIC/KASA	MRB	New	12th MP and beyond		Water footprint for 1kg of natural rubber produced. Project will be carried out in four regions - North, South, East and West of Peninsular Malaysia.
			Study on water use efficiency in oil palm plantation. Establish activities for determining high water use efficiency planting material using physiological approaches and data collection on physiological changes in oil palm.	Selected study site in Peninsular Malaysia and Sarawak	MPIC/KASA	MPOB/ Scientific community/ support for oil palm industry	New	12th MP	Not a project under MP. To increase oil palm yield.	Scientific journals published.
			Study on enhancement of oil palm water use efficiency in water deficit condition.	Regional	MPIC/KASA	MPOB/ Scientific community/ support for oil palm industry	New	13th MP	Not a project under MP. To increase oil palm yield.	Scientific journals published.
			Organise workshop to introduce new technology packages to pepper growers.	National	MPIC/KASA	MPB/DOA	New	12th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021	Workshop to introduce new technology packages to pepper growers.

		Public health emergency preparedness, climate-disease surveillance and coordination of environmental health data.	Develop an integrated database system of epidemics and environmental disasters that include infectious disease notification system, e-BAS system (e- Environmental Disaster Data System) and Inter-Agency Emergency Operation Centre Network (i-NET) (Centre for Disease Control) e.g. Food technology to increase productivity and adaptability to climate (university research).	National	MOH/KASA/ NADMA	MOH (CPRC)	New	12th MP	Integration of DRR & CCA	
			Strengthen (review) preparedness and response to extreme weather event (flood, heat wave, haze).	National	MOH/KASA/ NADMA	MOH	On-going activities	12th MP	Integration of DRR & CCA Use existing operational budget	
			Surveillance system and early warning system; identify and prioritise new emerging pollutants of water quality parameters.	National	MOH/KASA	MOH/KASA	New	12th MP and beyond	Including sanitary survey which is an element of the existing drinking water quality programme (KMAM) and is useful for identifying new emerging pollutants (see below for detailed explanations) Cooperation between KASA and MOH to identify new emerging pollutants such as Endocrine Disrupting Chemicals (EDC) and Antimicrobial Resistance (AMR). Institute of Medical Research (IMR) with Engineering Services Division, MOH also currently conducting a research on AMR in water supply system in Malaysia.	New emerging pollutants.
			Develop Drinking Water Quality Index (DWQI) using GIS through the cooperation with MYSA.	National	MOH/KASA	MOH/MYSA	New	12th MP and beyond	Pilot project in Selangor and Negeri Sembilan have been completed. To be extended to all states in phases starting 2022.	DWQI reporting.

			Develop environmental health information system for coordinating health data.	National	MOH/KASA	NEHAP Secretariat/ MOH/MOSTI KASA/KPKT/ DOSM	New	12th MP	System is in the planning stage. Data sharing with built in security -link all data in one database system e.g. water and health Linking between climate change-environmental determinants-human exposure- effects require big data, long term data and complex analysis (disease modelling & predictive analytics) Raw and drinking water, temperature and climate variables to identify high risk areas and population (pelan perancangan bandar tempatan/local township planning).	Environmental Health Information System.
			Develop climate-sensitive disease surveillance system; to integrate climate data with relevant diseases.	National	MOH/KASA	MOH/MET Malaysia/DOE	New	13th MP	No integration of climate data in disease surveillance system	
			Conduct vulnerability assessment of climate sensitive diseases.	National	MOH/KASA	MOH (IMR)	On-going activities	12th MP and beyond		
			Conduct impact assessment of climate sensitive diseases (Disease burden and disease projection study).	National	MOH/KASA	MOH (IMR)	New	12th MP and beyond		
			Provide training in disease surveillance, registry and admission data for data analysis and management, health risk assessment and field simulation (interagency data & information sharing); develop GIS real-time monitoring and health-based warning system.	National	MOH/KASA	MOH	New	12th MP and beyond	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.	
	Assimilating Knowledge to Improve Planning and Implementation	Vulnerability, hazards and emerging issues to address the impact of climate change and disasters.	Vulnerability and adaptation assessment (VNA) and emerging issue on climate and water-related diseases.	National	MOH/KASA	IMR/NAHRIM	New	12th MP and beyond		

			Vulnerability, Impact and Integration of Climate Change Adaptation and Disaster Risk Reduction; risk assessment of water-related disasters and geohazards.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Universities	On-going activities	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.	Equipped Malaysian Waters with Physical Oceanographic Sensors.
			Develop long-term physical oceanographic monitoring station across 14 Malaysia territorial water to understand climate change impacts (sea level rise) in Malaysia.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Relevant Government agencies	On-going activities	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.	5 guidelines, procedures and technical documents.
			Reconciliate among the dominance forces known as Silent Threats e.g. SLR, Active Zone for erosion and accretion, storm surges and land subsidence are among the niche / crucial field to be studied and research.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Relevant Government agencies / Private or NGOs	On-going activities	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal	2 Subject Matter Expert (SME) in Hydroclimate & 2 pilot site of nature based solution (NBS) adaptation projects.

							2 Subject Matter Expert (SME) in Hydroclimate & 2 pilot site of nature based solution (NBS) adaptation projects.
allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.				12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.	5 technical reports including CCA-DRR frameworks for water related disaster.
				On-going activities		13th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.
			NAHRIM/ Relevant Government agencies / Private or NGOs			NAHRIM/ Universities	
		KASA/NADMA				KASA/NADMA	
	National, State, District (Coastal Reach and Rivermouth)					National, State, District (Coastal Reach and Rivermouth)	
Address coastal and marine related disasters (e.g. tsunami, coastal sediment transport erosion & accretion) and develop guidelines for mitigation and adaptation plans.						Research on identification of sensitive and high vulnerability areas to the impact of climate change and natural disaster, as well as the study of disaster risk reduction frameworks.	

			Research and integrating of climate change data and information in planning and risk reduction actions related to water disasters through the development/improvement of guidelines, procedures and other relevant technical documents.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Relevant Government Agencies	On-going activities	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.	5 guidelines, procedures and technical documents.
			Research on capacity building programme and nature-based adaptation technology.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Relevant Government Agencies / Private or NGOs	On-going activities	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. NAHRIM intends to establish the Climate Change Research Centre as a focal point in this field, including developing a group of national hydroclimate experts (SMEs).	2 Subject Matter Expert (SME) in Hydroclimate & 2 pilot site of nature based solution (NBS) adaptation projects.
			Strengthen capacity and mechanism in risk assessment and implementation on water-related disaster and geohazard: i. consolidating and identifying silent threats to coastal ecosystem e.g. SLR, coastal active zone (erosion & accretion coastal segment; storm surges prone area; land subsidence along the coastal area).	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Relevant Government Agencies	On-going activities	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal	1 Subject Matter Expert (SME) in Hydrodynamic & 1 SME in Green Technology (Nature-based Solution (NbS) & Ecosystem-based Approach (EbA).

							allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.
						12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.
							Equipped Malaysian Waters with Physical Oceanographic Sensors to provide primary data for SLR and Climate Change Studies in Malaysia.
							allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.
						12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Safeguarding Malaysia coast from the impact of natural disaster and climate change impacts.
							Improving readiness to Malaysia Coast in facing the silent Threats from identified forces of Climate Change.
							Develop of long-term physical oceanographic monitoring station across 14 Malaysia territorial water to understand climate change impacts and collation of primary data acquired for hydrodynamic modelling works in Malaysia.
							Amplify and promote green infrastructure strategies to nationwide towards impacts of climate change & sea level rise in Malaysia.

			Research and study on improving resilience, vulnerability assessment, impact and adaptation of climate change on water resources and services.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Universities	New	12th MP and beyond	Integration of DRR & CCA Preliminary work for the updating of the NAHRIM RegHCM model based on IPCC AR6 will begin in 2022. IPCC Assessment Report will be revised for every 5 to 7 years. Expected revised year of IPCC Assessment Report: AR7 (2028), AR8 (2034) & AR9 (2040).	5 parameters of hydroclimate dataset output (up to year 2100) for 6x6 km Grid of AR6 (with 5 SSP scenarios) Regional Hydroclimate Model (RegHCM) for Malaysia.
			Research on identification of sensitive and high vulnerability areas to the impact of climate change and natural disaster, as well as the study of disaster risk reduction frameworks.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Universities	On-going activities	12th MP and beyond	Integration of DRR & CCA All the system will be improved, revised and updated based on updating data from AR5 (RCP Scenarios) NAHRIM RegHCM for 12th MP. All the system will be improved, revised and updated from time to time in line with revised versions and inputs of IPCC Assessment Report.	3 system/tools output: N-HyDaa v2, MAIN v1&v2 & Kemaman Flood Forecasting v2.
			Research on Coastal Reservoir as a new freshwater resource for the city / state with higher population and water-demand for various purposes e.g industries, irrigation and agricultural needs.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Relevant Government Agencies	Pilot Project	12th MP and beyond	Integration of DRR & CCA Successful track record in several densely populated and urbanised country e.g. China and India. Fresh Water Resources / option will strengthen KASA role in Water Scarcity issue / Gaps / solution in Malaysia.	Initiatives or potential solutions for water scarcity in the Country.
			Research and integrating of climate change data and information in planning and risk reduction actions related to water disasters through the development/improvement of guidelines, procedures and other relevant technical documents.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Relevant Government agencies	On-going activities	12th MP and beyond	Integration of DRR & CCA Output from this research activities will be used or adopted for incoming NC4 assessment (V&A chapter).	5 technical assessment reports on vulnerability, impact & adaptation assessment (VIA).

								National Communication (NC) must be updated for every 4 years and submitted to UNFCCC by KASA as focal point.
		Mainstream sea level rise and storm surge projections into the Integrated Shoreline Management Plan (ISMP) and for the planning of coastal protection and development projects.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Relevant Government agencies/ Private or NGOs	On-going activities	12th MP and beyond	Integration of DRR & CCA Budget approved in 12th MP under Sea Level Rise, Storm Surges and Coastal Geomorphology fund from EPU. IPCC Assessment Report will be revised for every 5 to 7 years. Expected revised year of IPCC Assessment Report: AR7 (2028), AR8 (2034) & AR9 (2040). Malaysia utilises the Coastal Vulnerability Index (CVI) associated with SLR, as an essential indicator to evaluate the vulnerability and risk levels of shoreline. This will be embedded in mapping out vulnerability assessment of different socioeconomic segments. Efforts will be focused on intensification of developing coastline SLR-based inundation maps.
		Increase diversification and exploration of alternative water sources such as urban scale rainwater harvesting system, groundwater, recycled and reclaimed water for conjunctive use; and prioritise water demand management to reduce stress on water supply, which is high on the agenda.	National, State, District (Coastal Reach and Rivermouth)	KASA/NADMA	NAHRIM/ Relevant Government Agencies	On-going activities	12th MP and beyond	Integration of DRR & CCA Currently under proposal to be tabled to KASA Fresh Water Resources / option will strengthen KASA role in Water Scarcity issue / Gaps / solution in Malaysia
								Produced detailed local SLR, coastal sediment transport inundation and flood prone potential across 14 states in Malaysia.
								Numerical modelling assessment on selected coastal and river mouth nationwide (Focus / Target on higher water-demand state in Malaysia).

			Establish Malaysia Grand Challenge (MGC); offer five (5) R&D Funding Schemes.	National	MOSTI/KASA	MOSTI	On-going activities	12th MP	subject to the budget approval under MP. These schemes encompass the 10-10 Malaysia Science, Technology, Innovation & Economy (MySTIE) Framework by the Academy of Sciences Malaysia (ASM). The socio-economic drivers are inclusive of Energy, Water & Food, Medical & Healthcare, Agriculture & Forestry and Environment & Biodiversity.	Produced detailed local SLR, coastal sediment transport inundation and flood prone potential across 14 states in Malaysia.
		Strategic and emerging issues across terrestrial margins and oceans.	Capture the impacts of environmental change on primary production in the South China Sea from space; variabilities and precursor features of extreme rainfall events over Malaysia and its neighbouring sea in the changing climate; impact of climate change towards seaweeds.	National & institution	MOHE/MAFI/ KASA	MOHE/ Universiti Malaya/ Universiti Sains Malaysia/ Department of Fisheries Sabah, Scottish Association for Marine Science, Natural History of Museum, UK	On-going activities	12th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.	Information on the changes in primary production over the past 20 years under the influence of climate change will be quantified. Precursor features at least month/months ahead of the extreme rainfall events. Publications and master students. Identify cultivated seaweed species that are resistance to temperature increased.

Strengthen impact assessment research in line with climate change adaptation through the research on new fish breeds/traits; enhance culture and nursery systems; fish health and emerging diseases; aquaculture - environmental issues; strengthen data collection; proper spatial planning (including GIS), early warning system and data sharing for aquaculture; species inventory; risk assessment of alien species; limnology and water quality; sanctuary establishment; public restocking; early warning system; proper spatial planning (including GIS); strengthen data collection and data sharing for inland fisheries; fish stock assessment; fish biology study; establishment of new Marine Protected Area; development of artificial reefs; oceanography and marine science; early warning system; resource friendly gear; strengthen data collection; data sharing and spatial planning and forecasting (RS/GIS) in capture fisheries.	National & State	MAFI/KASA	DOF STATE	New	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.	
Practice a monthly site visit to the port operating area to improve water quality and reduce the Port's water usage.	Internal/ Authority level	MOT/KASA	LPKTN/KPC/ Port Authority & Terminals	On-going activities	Continuous implemen-tation	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Kuantan Port Authority (KPA) & Port Klang Authority (PKA)	Comply with Water Quality Act.
Finance									
Investing in Disaster Risk Management	Disaster risk financing and social protection.	Conduct feasibility study, quantification of socio-economic impacts of disaster; develop policies on disaster risk transfer mechanism and establish alternative funds for disaster relief and recovery.	National	NADMA	MOF	New	12th MP	Consolidating financial protection.	Framework.

		Mainstreaming disaster risk management in public investment.	Provide development grant for cities to showcase best planning practices in climate-resilient efforts, IWRM, IRBM, ESA and climate change mitigation/adaptation and disaster risk reduction in land use planning. Conduct programme to recognise individuals, communities, institutions and Local Authorities which implement green neighbourhood initiatives such as urban farming, rainwater harvesting, composting and provision of pedestrian walkway. E.g.: Program Anugerah Kejiranan Hijau (AKH)	Federal	NADMA	PLANMalaysia /PLANMalaysia@State/Local Authorities	New	12MP and beyond Continuous implementation	i. Competition will be held to shortlist local authorities/cities with best planning practices in implementing IWRM, climate change mitigation/adaptation and disaster risk reduction in land use planning. This programme is open to all states in Malaysia. ii. Provide small development grants for selected local authorities/cities based on the result of the competition to upscale the implementation of IWRM, IRBM, ESAs, climate change mitigation/adaptation and disaster risk reduction in land use planning. iii. Replication of the best planning practices to other cities through knowledge sharing and seminar.	1 competition per year; 5 development grants per year; 1 seminar per year.
			Capture the impacts of environmental change on primary production in the South China Sea from space; variabilities and precursor features of extreme rainfall events over Malaysia and its neighbouring sea in the changing climate; impact of climate change towards seaweeds.	Federal	NADMA/KASA	PLANMalaysia / UTM/USM/ UPM/NAHRIM /JPS	New	12MP and beyond Continuous implementation	Research grant for local and foreign universities with research output in methodology, modelling and decision-making tools. Joint colloquium as a knowledge-sharing platform between universities, public institutions and industrial players. Compilation of research findings IWRM, IRBM, ESAs, Climate Change Mitigation, Adaptation, Disaster Risk Reduction and Landuse Planning.	10 Research Grant per year; 1 joint colloquium per year; 1 compilation of research per year.

									i. 10 research grant/ year = RM500,000 ii. 1 joint colloquium/ year = RM30,000 iii. 1 compilation of research findings = RM30,000 iv. research activities (data collections, TNT etc.) = RM40,000	
			Irrigation system and crop production technology for rural stakeholders: Subsidise irrigation system and white pepper production technology to rural stakeholders.	National	MPIC/KASA	MPB/DOA	New	12th MP and beyond	13th MP Project and beyond This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021.	Sufficient fund to rural stakeholders for adoption and implementation of new technologies.
	Strengthening Financial Capacity for Climate Resilience	Climate resilient and environment-friendly financing and alternative sources of income.	Conduct feasibility study for adaptation and resilience; scale-up climate resilient and environment-friendly financing and investment from the private sector, CSOs and individuals.	National	KASA	KASA	New	12th MP		
			Review the health financing mechanism.	National	MOH/MOF	MOF	New	12th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. (GDP 4.75%, 53% to MOH, the rest are insurance, out of pocket, health facilities, military health, etc.) Report MOH 2018 Source - tax Report ASM 2000 Needs to double amount of resources for health =9%/ social health insurance/ MySalam to B40 Indonesia e.g. Political will--freedom of speech--reform--decentralisation--	

								all provincial governments have responsibilities on Paper Lancet 2013 financial reform 1. Lack of technical capacity to run health financing system. 2. Lack of political will. 3. Influenced by private health insurance companies who lobby against social health insurance Social health insurance unites public and private healthcare system OECD report on climate change Service provider, policy maker, enforcement, research, training let university do research, leaving only 1 research centre; IMR	
			Provide insurance and disaster fund for fishers and farmers; financial loan with flexible repayment; development fund for fisheries department for all CCA programmes and operating fund for CCA programmes.	National	EPU/MOF/MAFI / KASA/NADMA	DOF	New	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Integration of DRR & CCA	Proper insurance system and disaster fund aid established; Proper financial aid for fishing / aqua companies; Substantial amount of budget; Substantial amount of budget.

Infrastructure & Technology									
Enhancing Early Warning Systems and Disaster Response	Framework for subsurface geological hazards and early warning for better preparedness of at-risk communities.	Subsurface geological systems: Develop DRM plan including regulations, early warning, monitoring and understanding of subsurface natural hazards through establishment of a database and geological models (2D,3D and 4D) in Greater Kuala Lumpur as a pilot.	National	NADMA/KeTSA	JMG/ DBKL/ State Government	New	12th MP and beyond	Disaster risk management (DRM) initiatives for unforeseen subsurface geological hazard and risk. Type of monitoring such as; i. Datum point and bench marker ii. Environmental geochemistry iii. Subsurface movement (e.g. tilt meter etc.) iv. Ground (stress and strain) stress magnitude and direction monitoring. v. Temperature, conductivity of ground water (dissolved mineral, level etc.) insitu borehole monitoring. Subsurface geology model and inventory; Subsurface DRM Plan and Early Warning System; and Regulations for Subsurface Development for Greater Kuala Lumpur. 13th MP, 14th MP & 15th MP will cover urban areas of the whole Selangor state.	Subsurface geology model and inventory; Subsurface DRM Plan and Early Warning System; and Regulations for Subsurface Development for Greater Kuala Lumpur.

			Subsurface geological systems: Develop DRM plan including regulations, early warning, monitoring and understanding of subsurface natural hazards through establishment of a database and geological models (2D,3D and 4D) for Ipoh, Johor Bahru, Penang, Kuching, Kota Kinabalu and all other states capital that include existing and expanding urbanised area.	National	NADMA/KeTSA	JMG/State Governments	New	13 MP and beyond	Disaster risk management (DRM) initiatives for unforeseen subsurface geological hazard and risk. Type of monitoring such as; i. Datum point and bench marker ii. Environmental geochemistry iii. Subsurface movement (e.g tilt meter etc.) iv. Ground (stress and strain) stress magnitude and direction monitoring. v. Temperature, conductivity of ground water (dissolved mineral, level etc.) insitu borehole monitoring. Subsurface geology model and inventory; Subsurface DRM Plan, Early Warning System, and Regulations for Subsurface Development for Ipoh, Johor Bahru, Penang, Kuching, Kota Kinabalu and all other states capital that include existing and expanding urbanised area.	Subsurface geology model and inventory; Subsurface DRM Plan, Early Warning System, and Regulations for Subsurface Development for Ipoh, Johor Bahru, Penang, Kuching, Kota Kinabalu and all other states capital.
		Land use scenario planning model and decision-support system for development control.	Develop land use scenario planning model for 13 local authorities, linking to their GIS system for better decision-support in planning and development control, integrating IWRM, IRBM, ESAs, Climate Change Mitigation, Adaptation, Disaster Risk Reduction and Land Use Planning.	Federal Local authority	NADMA	PLANMalaysia /Local Authority	New	15th MP	Develop land use scenario planning model (based on climate change impact eg.1.5°C rise) and develop decision support system integrating IWRM, IRBM, ESAs, Climate Change Mitigation, Adaptation, Disaster Risk Reduction and Land Use Planning for 14 local authorities. (1 local authority from each state in Malaysia	7 land use scenario planning models for 14th MP; 7 Land use scenario planning models for 15th MP.

									including Kuala Lumpur). i. 1 million for each local authority. ii. 7 local authorities for 14 MP (7 millions). iii. 7 local authorities for 15 MP (7 millions).	
	Developing Sustainable Infrastructure with Cost Effective Technology	Infrastructure and technology for flood and coastal protection.	Incorporate climate change factors (CCF) at river basin level into flood mitigation design to minimize the flood impacts and to include sea level rise factors in coastal protection structure design.	Federal	KASA/NADMA	JPS/NAHRIM	On-going activities	12th MP and beyond	Integration of DRR & CCA Currently JPS is using CCF according to region in Malaysia. New Study by JPS-NAHRIM needs to be conducted for safety and economical design to adapt the climate change impact in the future at river basin level.	Number of river basin.
			Develop and enhance existing infrastructures for NAWABS and NaFFWS with current and future technology related to climate change impact.	Federal	KASA/KeTSA/ MAFI/NADMA	JPS	On-going activities	12th MP and beyond	Integration of DRR & CCA Tubewell, Telemetry Stations, ICT Hardware and other infrastructures	
			Flood barrier door system: Conduct preliminary study, product development, product testing, patenting and promotion for the innovation in flood door used for housing area.	National	KASA/NADMA	JPS and Relevant Housing Authorities (owner of this innovation will be CENTA/PSIS)	New	12th MP and beyond	Integration of DRR & CCA The flood door will be installed at housing aread that are affected by flash flood.	Producing the best solution for the flood door that can be implemented in area that effected by flash flood.
			Remote sensing and related technologies: Identify shoreline changes and its impact to mangrove forest using Geospatial Techniques; and identify areas at high risk of coastal erosion as well as making projections of changes to the country's coastline.	National level	MOSTI/KASA/ KeTSA/NADMA	MYSA/ NAHRIM/JPS/ FDPM State/Local government	New	12th MP	Integration of DRR & CCA Shoreline is generated from satellite imagery, while shoreline changes, rate of change and change projection are analysed using geospatial technique. Shoreline changes at Tanjung Burung Forest Reserve, Perak over 32 years using geospatial technique.	Identify national shoreline changes.

		Health, water, food and energy nexus at the river basin level.	Safe drinking water supply: Improve low cost technology approach and upgrade water treatment system for alternative rural water supply.	National	KASA/MOH	KASA/KPLB/ JAKOA/MOH	On-going activities	12th MP and beyond	Upgrading all the alternative water supply for rural area with appropriate technology. Project under MOH Coverage only. Coverage for Safe Water Supply for Rural Area - 96.84%.	Coverage of clean water supply for rural area with water treatment system.
			Environmentally sustainable health care facilities: Develop green hospitals and green healthcare initiatives through the use of rainwater harvesting system, integrated water management system, water efficient fittings and etc.	National	MOH/KASA	MOH (Engineering/ SHD/DHD)	On-going activities	12th MP		
		IoT for agriculture and forest sectors to build climate resilience.	Water management for agriculture; Develop fertigation system equipped with soil sensor and IoT system for cocoa adaptation during extreme climate changes and optimise water usage in cocoa plants through IoT management.	National	MPIC/KASA	MCB	On-going activities	12th MP	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021	Fertigation system at Malaysian Cocoa Board (MCB) Research and Development Centre Bagan Datuk, Perak.
			Develop auto-control system of micro-irrigation in the cocoa nursery for optimum water usage purpose.	National	MPIC/KASA	MCB	On-going activities	13th MP	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021	Number of nurseries: approx. 50 nurseries house. Location: Malaysian Cocoa Board (MCB) Research and Development Centre Bagan Datuk, Perak.
			Develop water recycling system for kenaf bio-retting processing (under Program Kenaf Untuk Rakyat Secara Berkelompok bagi Pengeluaran Fiber Premium).	Multi State	MPIC/KASA	LKTN	On-going activities	12th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies on held 8 June 2021	Water recycling system for kenaf bio-retting processing in multiple states - Kelantan, Pahang, Melaka, Kedah, Perak and Johor.
			Develop water recycling system for kenaf pulp and paper processing (under the Program Tanaman Baharu Kenaf).	Multi State	MPIC/KASA	LKTN	On-going activities	12th MP	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021	Water recycling system for kenaf pulp and paper processing in Pahang and Perlis.

	Develop wastewater treatment system for Malaysia Pepper Board Sibu and Sarikei, Sarawak.	State	MPIC/KASA	MPB	On-going activities	12th MP	IECS to obtain the current level of effluent at both centres. The project has also already been awarded to successful tenderer This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021	Industrial Effluent Characteristic Study (IECS). Building of Wastewater treatment system at MPB Sibu and Sarikei.
	Peat and oil palm plantations: Conduct survey of peatland hydrology for specific study site in Sarawak, develop different water table in study site with replanting oil palm for monitoring of oil palm growth and productivity, replant the area with suitable clonal oil palm for deeper water table and monitor carbon balance and oil palm performance.	State (Sarawak)	MPIC/KASA	MPOB/Oil palm industry	New	12th MP		Scientific journals and Best Management Practices (BMP) of oil palm on peatland published.
	Implement new water management technology (IoT integrated irrigation system) on pepper farming among farmers.	National	MPIC/KASA	MPOB/Oil	New	13th MP	(Currently there is no standard irrigation system for pepper as most of pepper growers in Malaysia rely entirely on rainwater) This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021	IoT integrated irrigation system in pepper farming throughout Malaysia. Focus state: Sarawak, Sabah, Johor, Kedah, Kelantan & Terengganu.

			Implement new post-harvest technology (IoT application) on white pepper production among farmers.	National	MPIC/KASA	MPB/DOA	New	13th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021	(Production of white pepper is currently using flowing water from rivers and streams. This limits the production of high-quality white pepper). IoT application on white pepper production in Sarawak (first phase) and Peninsular Malaysia (second phase).
			Reduce Emissions from Deforestation and Forest Degradation (REDD Plus); Upgrade high-tech workstation towards the implementation of AI technology.	National	MOSTI/KASA	MYSA	New	12th MP	Current workstation almost reaching maximum capacity	
			Develop early warning systems to fisheries and aquaculture; relocate farms/cage from flood/drought prone areas and invest in indoor aquaculture system.	National	MAFI/KASA/ NADMA	DOF	New	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Integration of DRR & CCA	1. 1 system 2. Proper planning 3. Proper planning
			Use high resolution remote sensing data and Artificial Intelligence (AI) Technology for automated mapping of forest cover change; use Near Real Time forested area monitoring and change detection; use of hyperspectral data to support more detailed information needs; develop fully online data entry and processing; enhance collaboration with local experts (Research University) related to the latest technology.	National	MOSTI/ KeTSA/ MOHE/ KASA	MYSA/ Forestry Department/ Local University	On-going activities	12th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Forest cover mapping periodically every two years; In-House development of web-based Geographic Information System (GIS) application that comprises of geospatial and remote sensing information of forested areas.	
		Risk reduction and adaption for strategic infrastructure.	Establish an emergency flood mitigation system at airports (Kuala Terengganu Airport, Kota Bharu Airport, Alor Setar Airport, Kuantan Airport, Kota Kinabalu Int. Airport, Ipoh Airport); complete water treatment plant for alternative water supply at KLIA and supply treated water from Southern Balancing Pond (SBP);	River Basin Level	MOT/KASA/ NADMA	State Level	New	12th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Integration of DRR & CCA Planning/ System Study;	Planning; completion of Water Treatment Plant (WTP); completion of the RWH system installation at 7 MASB airports.

			use recycle natural rain water for irrigation purposes in Penang Int. Airport, Kota Kinabalu Int. Airport, Kuching Int. Airport, Langkawi Int. Airport, Kota Bharu Airport, Kuala Terengganu Airport and Miri Airport.						collaboration with Business Partner	
			Conserve energy and maximize energy efficiency of Port operations; reduce waste from port operations through material reuse, recycling and composting; promote economic, social and cultural progress through an environmentally sound and sustainable development within port area.	Authority Level & District Level	MOT/KASA	Port Authority & Terminals	On-going activities	Continuous implementation	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Port Klang Authority (PKA)	Save on energy consumption of port operations; manage and monitor waste disposal effectively; fulfil the aspiration for sustainable development.
			Use more energy efficient and environmentally friendly equipment (VRF system and R-32 cooling on all air conditioners); collect rainwater for daily operational use such as cargo watering, bay washing and dock washing and retreat water throughout the port area to reuse for post-port operations purposes; use LED/CFL lights throughout the port area in stages as well as explore and implement other appropriate energy efficiency initiatives; use hybrid RTG and on-shore power supply for long-term plan.	Internal	MOT/KASA	LPKTN/KPC	On-going activities	Continuous implementation	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Kuantan Port Authority (KPA)	
	Enhancing Disaster Preparedness and Recovery	Resilient construction guidelines and standards for retrofitting and reconstruction of damaged buildings and infrastructure.	Develop design code related to earthquake resilient infrastructure, resistance and retrofitting of building.	National	NADMA	JSM	On-going activities	12th MP and beyond	a. MS EN 1998-1, Design of Structure for earthquake resistance -Part 1: General rules, seismic actions and rules for buildings and its National Annex (Completed); b. MS EN 1998-2, Design of Structure for earthquake resistance -Part 2 : Bridges (in-progress, target completion date : Q2 2023) c. MS EN 1998-3, Design of Structure for earthquake resistance -Part 3: Assessment and retrofitting of buildings	

d. MS EN 1998-4, Design of Structure for earthquake resistance -Part 4: Silos, tanks and pipelines e. MS EN 1998-5, Design of Structure for earthquake resistance -Part 5: Foundations, retaining structures and geotechnical aspects f. MS EN 1998-6, Design of Structure for earthquake resistance -Part 6: Towers, masts and chimneys

Appendix G WST2040 Road Map with Budget Requirements

Focus Area	WST2040 Budget Requirements 12MP/13MP/14MP/15MP Budget (RM '000,000)														
	Strategy	**Programmes/ Initiatives**	**Activities**	**Lead Ministry Organisation**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total 12MP**	**13MP**	**14MP**	**15MP**	**Target Completion**	**Remarks**
People	**Enhancing Community Engagement and Capacity in Disaster Management**	Community-based activities including drills to engage stakeholders in disaster-prone areas across all phases of disaster management.	Plan and implement community-based activities including drills with stakeholders, to engage private sector, civil society organisations, youth, women and vulnerable groups in disaster-prone areas to undertake disaster risk management, preparedness, response, recovery and building back better efforts.	NADMA	-	-	3	3	3	9	9	9	10	12th MP and beyond	Estimation with NADMA as the coordinator
		Capacity building for disaster managers in local authorities and operational agencies for area-specific risk and simulation exercises with multiple partners.	Provide hands-on technical training for local authorities and other operational agencies in area-specific risk types to develop specialised prevention, preparation and response programmes, including counselling services for post-disaster trauma and simulation exercises.	NADMA	-	-	2	2	2	6	6	6	8	12th MP and beyond	Estimation with NADMA as the coordinator
	Empowering People for Strengthening Adaptive Capacity to Climate Change	Awareness training and community-based adaptation efforts to engage local communities in vulnerable areas to build climate resilience.	Conduct awareness training and community-based adaptation efforts to build climate resilience, including the understanding of climate change, water, food and health nexus and engage local communities in vulnerable areas.	KASA	-	-	1	1	1	3	5	5	5	12th MP and beyond	CEPA and information dissemination
		Technical capacity building across relevant sectoral ministries and agencies at all levels for adaptation planning, implementation and reporting.	Conduct technical capacity building across relevant sectoral ministries and agencies for adaptation planning, implementation and reporting at all levels, including handling of gender issues, vulnerable groups and international negotiation.	KASA	-	-	1	1	1	3	5	9	5	12th MP and beyond	
			Conduct attachment programme (internal and external), development course for implement officer and staff, create Subject Matter Expert (SME) and promote awareness to fishers and farmers in workshop, consultation session; and efficient coordination between external organisation to provide better information dissemination system to the vulnerable group.	MAFI/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.

			Interact with and educate the community regarding port operations and environmental programmes and conduct campaigns for the implementation of electricity saving and energy efficient initiatives.	MOT/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	Continuous implementa-tion	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Port Klang Authority (PKA) & Kuantan Port Authority (KPA)
		Competency training and certification for environmental professionals with knowledge of climate and disaster risks.	Provide unique training course which focuses on hands-on approach in scheduled waste management.	KASA	-	0.015	0.05	0.015	0.015	0.095	-	-	-	12th MP and beyond	2025-Centre Of Environmental Technology PSIS will be offering consulting work for the community and industrial. A Certificate of Competency will be awarded to participants who successfully complete the course, passes the examination and submits a field training report and attend professional interview at EiMAS.
			Provide training course to train EO for EIA project with land disturbing activities, construction and operation of the entire project to become competent, skilled and trained professional in environmental management and pollution control.	KASA	-	0.015	0.05	0.015	0.015	0.095	-	-	-	12th MP and beyond	2025-Centre Of Environmental Technology PSIS will be offering consulting work for the community and industrial. Certified Professional Environmental Officer in EIA Project Development and Operation (CePEOEIA)
			Provide Certificate of Competency in effluent management to participants who successfully complete the course, pass the examination, submit a field training report and attend professional interview at EiMAS.	KASA	-	0.02	0.05	0.015	0.015	0.1	-	-	-	12th MP and beyond	2025-Centre Of Environmental Technology PSIS will be offering consulting work for the community and industrial. Certified Environmental Professional in The Operation of Industrial Effluent Treatment Systems (Biological Processes – Activated Sludge Process)
			Set forth the criteria of competence for accreditation of testing / calibration performed by a laboratory or an organisation that carries out testing and/or calibration at or from a permanent location; at or from a temporary facility; or in or from a mobile facility.	KASA	-	0.02	0.02	0.02	0.02	0.08	-	-	-	12th MP and beyond	Certification of Environmental Testing Laboratory under Laboratory Accreditation Scheme of Malaysia (SAMM) MS ISO/IEC 17025

	Community-based adaptation for the water sector in river basins to promote engagement of multiple stakeholders.	Provide training based on training module of Advocacy Awareness and Capacity Building.	KASA	10	10	10	10	10	50	50	50	50	12th MP and beyond	Currently awareness programmes fund in JPS is under project cost basis, no dedicated allocation is given. Based on Training Module of Advocacy Awareness and Capacity Building (AACB) Task Force
	Technical capacity building for health professionals on management of climate sensitive diseases and outbreaks during disasters.	Climate change and health vulnerability and adaptation assessment (VNA).	MOH/KASA	-	-	0.08	-	0.08	0.16	-	-	-	12th MP	Attachment at Climate Change Centre in Germany or equivalent centre in other countries monitoring mechanisms development can be part of EHIS costs to manage the climate sensitive diseases
		Climate resilient health care facilities.	MOH/KASA	-	-	-	0.05	-	0.05	-	-	-	12th MP	In house training (SHD & DHD) location and relocation of healthcare facilities away from disaster areas (Bahagian Perancang)
		Health co benefit of climate change mitigation.	MOH/KASA	-	-	-	-	-	-	0.1	-	-	13th MP	In healthcare wastes incineration, energy, patient transportations to hospitals
		Provide training for preparedness, table top training, big data analysis and management starting at university level and strengthen the role of health education officers for risk communication, health promotion to community and media (FB).	MOH/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	12th MP and beyond	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.
	Capacity building of trainers and teachers on climate change and sustainable water resources management.	Train and retrain teachers on activities that are related to water resource management.	KASA	-	-	-	-	-	21,157 teach-ers 1.06	42,314 teach-ers 2.12	63,47 teach-ers 3.17	84,628 teach-ers 4.23	12th MP and beyond	

			Plan and conduct structured teacher professional development for in-service teachers based on the guidebook or teaching module on water sustainability by ASM. (BPG)	KASA	-	-	-	-	-	-	0.007	0.007	0.007	12th MP and beyond	i. Streamline land use planning with water resource management (IWRM), Integrated River Basin Management (IRBM) and other environmentally sensitive areas (ESAs), integrating climate change mitigation/ adaptation and disaster risk reduction;
			Train the trainers and teachers using various approaches of training such as face to face, online, and hybrid. (IPGM)	KASA	-	-	-	-	-	0.007	-	-	-	12th MP and beyond	ii. Climate Science and its relationship with land use planning (impacts and causes);
			Develop inquiry-based climate change pedagogical resources for formal and non-formal settings, including resources for teachers' professional development.	KASA	-	0.1	-	-	-	0.1	-	-	-	12th MP and beyond	iii. Science-based decision making based on forecast climate change scenarios (e.g. temperature rise, sea level rise); Example: http://www. canadiangeograp hic. com/educational_product s/activities/climate_ change_l esson_plans/ EN/Living_Worl d%20_Activities/Climate-Change-Lesson-Plan_Living_World_ Teachers _Guide.pdf
			Train the trainers and teachers using various approaches of training such as face to face, online, and hybrid. (IPGM)	KASA	-	-	-	-	-	21,157 teach-ers and Train-ers 1.06	42,314 teach-ers and Train-ers 2.12	63,471 teach-ers and Train-ers 3.18	84,628 teach-ers and Train-ers 4.24	12th MP and beyond	iv. Science-based decision-making based on development scenarios; and
			Conduct professional development programme to familiarise teachers with climate science, active pedagogy and project design.	KASA	-	-	-	-	-	21,157 teach-ers and Train-ers 1.06	42,314 teach-ers and Train-ers 2.12	63,471 teach-ers and Train-ers 3.18	84,628 teach-ers and Train-ers 4.24	12th MP and beyond	v. Regulatory framework for IWRM, IRBM and ESAs through effective land use planning. Structured teacher professional development for in-service teachers will be based on the guidebook or teaching module on water sustainability by ASM (BPG). Train the trainers and teachers using various approaches of training such as face to face, online, and hybrid. (IPGM)

			Develop a climate literacy assessment instrument.	KASA	-	0.02	-	-	-	0.02	-	-	-	12th MP	The instrument is developed during 12 MP.
			Establish a single, searchable, user-friendly online resource for finding water- and climate-related education programmes and resources and funding opportunities (using a new or enhanced platform).	KASA	-	1	-	-	-	1	-	-	-	12th MP	The online platform is developed during 12 MP.
			Expand digital platforms/tools for teaching and learning and develop simulation-based games, mobile platforms, virtual environments, and augmented reality tools to heighten curiosity and increase learner engagement.	KASA	-	1	-	-	-	1	-	-	-	12th MP	The digital platforms/ tools are developed during 12 MP.
			Promote awareness among school children by organising a webinar on the importance of water and the impacts of climate on water resources.	KASA	-	0.05 44	0.05 44	0.05 44	0.05 44	0.272	0.272	0.272	0.272	12th MP and beyond	Annual event. Student presents in the webinar. Token of appreciation to be given to the all participants at national and state level. Estimated budget (yearly): i. National level- RM16K ii. State Level-RM38.4K
			Educate present and future generations about climate change by providing tools to help students learn science and geography more fun and effectively.	KASA	-	-	-	-	-	Green House 92.91 Water Distillation Equipment: 5.09 Meteorological Station: 6.11	-	-	-	12th MP	Involving 2,445 secondary schools
			Develop blueprint and GRI report system to enhance generic skill, knowledge and implement sustainable lifestyle that focuses on SDGs and blueprint's field of focus.	KASA	-	-	-	-	-	-	0.2	-	-	13th MP	Blueprint POLYGreen Politeknik Malaysia (BPPM) and Blueprint Smartgreen PolyCC (BSGPC)

			Develop Green Curriculum for all Malaysian polytechnic and community college programmes to produce graduates that are recognised by industry (green collar job).	KASA	-	-	-	0.03	0.03	0.06	-	-	-	12th MP and beyond	Blueprint POLYGreen Politeknik Malaysia (BPPM) and Blueprint Smartgreen PolyCC (BSGPC)
			Organise or offer courses/ programmes that emphasise on skills in green technology and sustainability to produce 4IR TVET graduates and responsive to industrial needs and SDGs.	KASA	-	0.375	0.375	0.375	0.375	1.5	-	-	-	12th MP and beyond	Sustainability Development Skills Programme for Polytechnics and Community Colleges towards Green TVET
			Develop teacher professional development workshop module and pedagogical activities (for formal and non-formal settings) on water sustainability and climate change adaptation.	KASA	-	0.02	-	-	-	0.02	-	-	-	12th MP	The content for the module on water sustainability is developed during the 12th MP. Based on Training Module for Academia under AACB Example: https://www.mrcmekong.org/assets/Publications/Manuals-and-Toolkits/BDP-Training-Manual-final-2011-update260112.pdf https://serc.carleton.edu/teac hearth/activities/236363.html
			Compile local and international case studies on the best practices of river/ water management and climate change adaption.	KASA	-	0.02	-	-	-	0.02	-	-	-	12th MP	The case studies on the best practices of river/ water management are compiled during the 12th MP. Based on Training Module for Academia under AACB
			Education on water and climate change: Promote digital literacy through reading digital materials on water and climate change (one of the activity under school resources centre).	KASA	-	25% of schools 2,555 schools	25% of schools 2,555 schools	25% of schools 2,555 schools	25% of schools 2,555 schools	10,220 schools 1.022	10,220 schools 1.022	10,220 schools 1.022	10,220 schools 1.022	12th MP and beyond	All schools (10,220) in Malaysia Based on Training Module for Academia under AACB

			Arrange education programmes that involve learners use open government data related to water and climate change in data-driven decision making.	KASA	-	-	-	-	-	8220 schools 0.08	1,644 schools 0.16	2,466 schools 0.25	3,288 schools 0.33	12th MP and beyond	50% of the total schools (16,440) in Malaysia Based on Training Module for Academia under AACB
			Offer bachelor course in Sustainability and Green Technology (PALS1012) and master course in Climate Change in the Tropics.	KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	12th MP and beyond	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Kurikulum ini akan diguna pakai mulai ambilan Jun 2022.
			Develop educational resources and activities on water and climate change in Digital Educational Learning Initiatives Malaysia (DELIMa) platform.	KASA	-	N/G	N/G	N/G	N/G	-	-	-	-	12th MP and beyond	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. The online platform is to be developed during 12 MP. Continuous enhancement of educational resources and activities on water and climate change in DELIMa
	Strengthening Capacity of Operational Agencies at the River Basin Level	Capacity building for integrating disaster risks and long-term climate hazards through spatial integration.	Train urban planners and supporting staff from the public (federal, state and local levels), private sector (members from the Malaysian Institute of Planners and other related professional bodies such as engineers, landscape architects, architects and surveyors) in spatial integration of DRR and CCA; and conduct attachment programmes (external) through skill share programmes in developed countries.	NADMA	-	1	1	1	1	4	5	5	5	12th MP and beyond	Training for trainers in 2022 and 2023. Those who have been trained in 2022 and 2023 will be the trainers for the following batches.
Governance	**Strengthening Governance and Partnerships at All Levels**	National policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR.	Develop a national policy on disaster risk management, multi-level disaster resilience plans and legislation on DRR to strengthen institutional arrangements.	NADMA	-	-	1	-	-	1	5	5	5	12th MP and beyond	2023: Proposal to update strategies/plans for climate extreme events (1mil) 13MP: Scaling up strategies to cover all states. 14MP: Formulation of legislation, revision of national and local strategies. 15MP: Focus on man-made and Natech

		Human capital for state and local levels, to further improve the efficiency of disaster response measures.	Strengthen disaster risk management through establishment of NADMA office at state level.	NADMA	-	-	-	-	-	-	50	100	50	13th MP and beyond	13MP: Establishment of state operations (subject to restructuring) 14MP: Upgrading of infrastructure. 15MP: Operations and management.
		Adaptation actions, implementation, monitoring and reporting of climate change adaptation progress at all levels.	National adaptation action plan for reporting and implementation and monitoring of climate change adaptation at all levels.	KASA	-	-	1.5	1	1	3.5	10	10	10	12th MP and beyond	KASA as the coordinating agency
		CCA centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for informed decision-making at all levels.	Establishment of a CCA centre to strengthen cross-sectoral collaboration between government agencies and all other stakeholders for better coordination, effective implementation and informed decision-making at all levels.	KASA	-	-	-	0.5	1.5	2	20	10	10	12th MP and beyond	2024: feasibility study
	Adopting Integrated Approaches for Climate Change Adaptation and Disaster Risk Reduction	Land use and spatial planning governance at all levels for integrating climate adaptation and disaster risks.	Study the roles of land use and spatial planning governance in Peninsular Malaysia (National Physical Planning Council (Federal Level), Regional Planning Committee (Regional Level), State Planning Committee (State Level), OSC Committee Meetings (local authority level)]. The study includes proposing a mechanism to plan, coordinate and control development based on the river basin. Study on innovative financing mechanisms to encourage and incentivise states and local authorities to preserve water resources areas and adopt sustainable land use planning by mainstreaming IWRM, IRBM, ESAs, climate change mitigation/adaptation and disaster risk reduction.	NADMA	-	-	0.5	0.5	-	1	-	-	-	12th MP	The levels include the National Physical Planning Council (Federal Level), Regional Planning Committee (Regional Level), State Planning Committee (State Level), OSC Committee Meetings (local authority level)]. 1. To expand the role and responsibility of every level of land use and spatial planning governance in Peninsular Malaysia to integrate water resource management (IWRM), Integrated River Basin Management (IRBM), and Environmentally Sensitive Areas (ESAs) into climate change mitigation/adaptation and disaster risk reduction. 2. Coordination of inter-state and inter-sectoral policies, planning, implementation and monitoring of development activities. 3. Land Use Planning and management of IWRM, IRBM and ESAs.

		Guidelines for disaster resilient cities to address climate extremes and integration of low carbon cities, sponge city and smart city for nation-wide adoption.	Formulate disaster resilience guidelines, preparedness plans, building codes and retrofitting approaches for critical buildings and infrastructure in cities, to integrate low carbon city, sponge city, smart city, etc. for nation-wide adoption in cities and townships.	NADMA/ KASA /KPKT	-	-	-	2	3	5	10	10	10	12th MP and beyond	To be jointly implemented with the programmeon low carbon and smart cities.
		Smart partnerships and coordination platforms to strengthen the health, disaster and climate nexus.	Strengthen coordination platform which relates to environment & health; and climate sensitive diseases. (eg. NEHAP).	MOH/KASA	0.5	0.5	0.5	0.5	0.5	2.5	2	2	2	12th MP and beyond	NEHAP is coordinated by the MOH and has the cooperation of various agencies related to environmental health. However, no specific allocation was channeled for the implementation of NEHAP.
			Public health standard on drinking water quality- gazette and enforce the Drinking Water Quality Act (DWQA) and regulations.	MOH/KASA	-	-	19.3	15	15	49.3	75	75	75	12th MP and beyond	Operating budget There are currently no laws and regulations regarding drinking water quality. The implementation of drinking water monitoring is based on administratively through the cooperation of relevant parties and stakeholders.
			Assess the resilience status of healthcare facilities to climate change and disaster risks.	MOH/KASA	-	-	0.1	-	-	0.1	0.1	-	-	12th MP and beyond	Healthcare facilities vulnerability and adaptation assessment (VNA) 10% out of total healthcare facilities annually
			Manage climate sensitive diseases including control of vector borne diseases through the Wolbachia program.	MOH/KASA	3.00 (20 localities)	5.26 (35 localities)	6.02 (40 localities)	6.77 (45 localities)	7.52 (50 localities)	28.57	-	-	-	12th MP	After 2 years of implementation, all localities in phase 1 have shown reduction in number of Dengue cases. Implementation cost per locality: RM 45,742.13 for capital cost RM 104,638.67 for maintenance cost Total cost: RM 150,380.8 Wolbachia Aedes mosquito operationalization in 20 localities with high Dengue burden

			Strengthen steering committee link with technical committee with regular meetings; review on priority area in climate change and health (NEHAP TWG 10) including emerging and remerging diseases and develop policy brief on Climate Change and Health (NEHAP TWG 10/TWG 5/NAHRIM; provide leadership training; enhance and integrate disease control and prevention management; promote self-regulation (self-assessment, monitoring) with mitigating actions; and assess healthcare system to enable planning and implementation of adaptive management strategies.	MOH/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	12th MP and beyond	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.
		Partnerships, coordination platforms and framework for integrating climate and disaster risks.	Implement MyGAP and registration for all farms (small and large) in aquaculture sector; strengthen Fisheries Management Plan, eliminate IUU fishing, establish more MPA and conservation areas, develop more artificial reef, stop overexploitation and further develop high seas fisheries; standardise states' inland fisheries enactments, establish proper and coordinated management of inland water bodies, pollution prevention and public restocking.	MAFI/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.
			Collaborate with UPNM in the study of the development of Wave Energy Converter (converting wave kinetic energy to electrical energy); strengthen engagement of stakeholders, public & related OGAs to provide equal weight to economic, social concern and environmental in the decision-making process; develop master plan for port development taking into account climate change adaptation and establish coordination, implementation of facilities that climate resilient.	MOT/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	Continuous implementa-tion	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Kuantan Port Authority (KPA), Port Klang Authority (PKA), and Penang Port Commission (PPC)
		Comprehensive groundwater governance at all levels to support conjunctive use of surface water and groundwater for implementing IWRM.	Set up a standing committee on groundwater by the National Water Council.	KeTSA/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	12th MP	

	Strengthening Regional Linkages on Disaster Risks, Climate Change and IWRM	International linkages on disaster management for joint technical programmes and simulation exercises.	Strengthen linkages with ASEAN and other international platforms (UNDRR, etc.) on joint technical programmes, training, simulation exercise, etc.	NADMA	-	-	-	-	-	-	2	2	2	13th MP and beyond	International and regional programmes organised by Malaysia.
Information & RDIC	**Implementing Evidence-Based and Risk-Informed Actions**	Multi-hazard risk management and vulnerability assessment for extreme events and cascading hazards, high-risk and sensitive areas and communities.	Expand multi-hazard risk management and vulnerability assessment for extreme weather events and cascading hazards for prevention, forecasting, monitoring, early warnings and control measures according to types of disaster (Flood, Landslide, Storms, Earthquake, Natech etc.).	NADMA/ MOSTI/ KASA/KeTSA	4.5	-	-	-	-	4.5	15	20	30	12th MP and beyond	12th MP: Tsunami risk assessment, NRR for man-made and rapid & slow on-set risk assessments. 13th MP: Expansion to local level scale and coverage of more hazards (natural & man-made) for selected pilots. 14th MP: Expansion to local level scale and coverage of more hazards (natural & man-made). 15th MP: Expansion to local level scale and coverage of more hazards (natural & man-made).
		Establish a multi-hazard data centre and risk register platform for efficient information sharing and risk communication through use of ICT.	Strengthen a one-stop environment-related data centre by improving data sharing among various stakeholders, including the private sector and CSOs to support decision-making.	NADMA	-	12	-	50	-	62	150	50	50	12th MP and beyond	12th MP: Feasibility and upgrading of NDCC. 13th MP: Development of centralised disaster information platform. 14th MP: Maintenance and expansion to state level. 15th MP: Maintenance and expansion to state level.
		Streamline land use planning for river basins and administrative boundaries.	Conduct pilot studies to streamline land use planning with IWRM (environmental units), IRBM, ESAs, climate change adaptation and disaster risk reduction.	NADMA	-	-	3	4.5	1.5	9	-	-	-	12th MP	i. Conduct pilot studies for 2 River Basins and 1 coastal area. ii. Develop a land use scenario planning model (based on climate change impact eg.1.5°C rise) and develop decision support system for every case study: - 1 Coastal Area (scenario of temperature rise, sea level rise and development trend). - 2 River Basin (scenario of temperature rise, development trend and water consumption). iii. Propose future land use planning based on scenario planning.

			Mainstream IWRM, IRBM, ESAs, climate change adaptation and disaster risk reduction into administrative development plans (local plan and special area plan) to plan for Climate Resilient Cities and Hinterlands.	NADMA	-	-	-	1.75	4.25	6	2.5	-	-	12th MP and beyond	i. Incorporate findings from River Basin Land Use Planning and Management Plan and Coastal Land Use Planning and Management Plan into 2 local plans and 3 special area plans in: - 1 local plan in an urban setting; - 1 local plan in a rural setting; - 1 special area plan in a coastal area; - 1 special area plan in high-density city; - 1 special area plan for hilly terrain area ii. Develop a land use scenario planning model (based on climate change impact, e.g. 1.5°C rise) and develop analytical tools for rationalising river basin boundary with administration boundary. iii. Mainstream IWRM, IRBM, ESAs, climate change mitigation/ adaptation and disaster risk reduction into spatial plans. iv. Develop decision-making tools based integrating IWRM, IRBM, ESA and climate change mitigation/adaptation and disaster risk reduction. v. Develop planning guidelines as a guide for development control. i. 1 River Basin Land Use Management Plan (2023 -2024) - 3 million

															ii. 1 Coastal Land Use Management Plan (2023 -2024) - 3 million iii. 1 River Basin Land Use Management Plan (2024-2025) - 3 million Modelling System to be completed in the 1st 6 months.
	Monitoring and assessment of emerging groundwater hazards to improve groundwater management and disaster preparedness.	Undertake vulnerability assessment and climate change impacts in water stressed areas, communities & sectors for groundwater.	NADMA/ KeTSA	-	-	-	1.5	2	3.5	30	40	50	12th MP and beyond	Expand integrated weather & sea level rise impacts on groundwater aquifers; develop & establish integrated transboundary groundwater management system; Transboundary Aquifer Monitoring (TMA) & Total Maximum Daily Pumping (TMDP); and enhance groundwater station for groundwater quality monitoring & water auditing (water cycle/water balance); monitoring wells with lysimetric instrument.
		Conduct groundwater hazards mapping, monitoring to develop early warning system for effective multi-scale disaster response.	NADMA/ KeTSA	-	-	-	-	-	-	35	35	35	13th MP and beyond	Integration of DRR & CCA
Enhancing Capability for Data Driven Decision-making	Weather, climate and geophysical information services for water related hazards such as flood, drought and tsunami.	Strengthen the surface meteorological observations networks (maintaining, upgrading & adding).	KASA/ NADMA	1.00	5.00	-	4.00	6.00	16.00	10.00	10.00	10.00	12th MP and beyond	Integration of DRR & CCA
		Strengthen the weather radar and satellite systems (maintaining, upgrading & adding).	KASA/ NADMA	30.00	25.00	4.00	-	29.00	88.00	30.00	30.00	30.00	12th MP and beyond	Integration of DRR & CCA Two radar stations for each MP.
		Empower Meteorological Main Computing System for generating, processing and display of weather forecasting and warning.	KASA/ NADMA	-	1.30	4.00	9.00	6.00	20.30	25.00	30.00	30.00	12th MP and beyond	Integration of DRR & CCA Towards implementation of cloud computing technology and fulfil the requirements of green technology in ICT.
		Enhance earthquake and tsunami monitoring and early warning systems.	KASA/ NADMA	-	-	-	-	-	-	8.00	8.00	9.00	12th MP and beyond	Integration of DRR & CCA

			Strengthen seismic, tsunami siren and tide gauge monitoring networks.	KASA/ NADMA	6.19	8.12	-	-	-	14.31	10.00	25.00	10.00	12th MP and beyond	Integration of DRR & CCA 14MP for upgrading system.
			Enhance climate database and products (Fire Danger Rating System, Heatwave etc.).	KASA/ NADMA	2.10	2.80	-	-	-	4.90	5.00	15.00	5.00	12th MP and beyond	Integration of DRR & CCA 15MP for upgrading system. Aims to provide comprehensive outputs in term of meteorological information and services for the use of relevant authorities, general public, media and others.
			Develop new method of cloud seeding using UAV/ Drone and LIDAR technology.	KASA/ NADMA	-	-	-	-	4.00	4.00	20.00	-	-	12th MP and beyond	Integration of DRR & CCA 12MP for testing, 13MP purchasing UAV
		Climate science and modelling for planning and implementation to support decision-making at the river-basin level.	Develop the Mesoscale Ensemble Prediction System (seasonal prediction + climate projection).	KASA/ NADMA	6.49	-	-	-	-	6.49	-	-	-	12th MP and beyond	Integration of DRR & CCA Eventual goal to produce a multiscale global model specifically focusing on the tropics to enhance weather and climate services in Malaysia. Eventual goal to produce a semi-hemispheric global model to drive the high-resolution models for weather and climatic scales to have a better understanding on extremes in the tropics for disaster preparedness. Model information will be used by various sectors such as Agriculture (food security), Flood Modelling and Disaster preparedness, Dam and reservoir management, preparation of climate action plan for megacities in Malaysia, Disaster management for weather and climate related extremes for local authorities.
			Improve numerical weather modelling product (WRF subkm).	KASA/ NADMA	-	-	10.00	38.00	-	48.00	100.00	-	200.00	12th MP and beyond	

	Improve Climate Change Resilience in Megacity through Mainstreaming Climate Urban Downscaling Projection (urban microclimate modelling).	KASA/ NADMA	-	-	-	-	-	50	-	100	13th MP and beyond	Integration of DRR & CCA Eventual goal to produce a multiscale global model specifically focusing on the tropics to enhance weather and climate services in Malaysia. Eventual goal to produce a semi-hemispheric global model to drive the high-resolution models for weather and climatic scales to have a better understanding on extremes in the tropics for disaster preparedness. Model information will be used by various sectors such as Agriculture (food security), Flood Modelling and Disaster preparedness, Dam and reservoir management, preparation of climate action plan for megacities in Malaysia, Disaster management for weather and climate related extremes for local authorities.
	Atmospheric pollution-related monitoring and modelling; simulate air pollution dispersion employing WRF/CMAQ modelling platform.	KASA/ NADMA	-	-	-	1.5	1.5	3	-	-	12th MP and beyond	Integration of DRR & CCA
	Strengthen the National GHG monitoring station and other atmospheric pollutants (maintaining, upgrading & adding).	KASA/ NADMA	2.00	2.80	-	-	-	4.80	15.00	-	12th MP and beyond	Integration of DRR & CCA GHG and atmospheric pollutants become major problem especially over megacities. Early warning system for GHG and other atmospheric pollutants is essential
	Simulate dynamics and interconnections between three major subsystems of the globe, namely, climate, biosphere, and society with respect to greenhouse gases emissions.	KASA/ NADMA	-	-	-	-	-	-	10	-	12th MP and beyond	Integration of DRR & CCA Outputs will include cumulative greenhouse gas emissions, resulting atmospheric concentrations, global warming, sea level rise, agricultural impacts, ecosystem risks, and also costs of policies for emissions reduction or control.

		Climate change impacts on water resources and supply at the river basin scale.	Expand National Water Balance System (NAWABS) and National Flood Forecasting and Warning system (NaFFWS) to other river basins in Malaysia and enhance existing NAWABS and NaFFWS model with current and future technology related to climate change impact.	KASA/ KeTSA/MAFI/ NADMA	24	24	24	24	24	120	120	120	120	12th MP and beyond	Integration of DRR & CCA Cost for Model and system development and enhancement.
		Smart technology for irrigation systems and crop production.	Implement IoT and sensor technologies in irrigation system application for traditional pepper farms.	MPIC/KASA	0.08	0.03	0.03	-	-	0.14	-	-	-	12th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/agencies held on 8 June 2021.
			Implement IoT and sensor technologies in production of white pepper berries.	MPIC/KASA	0.03	0.02	0.02	0.02	0.02	0.11	-	-	-	12th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/agencies held on 8 June 2021.
			Develop water footprint for sustainable natural rubber production.	MPIC/KASA	-	-	-	0.075	0.07	0.145	0.065	-	-	12th MP and beyond	
			Study on water use efficiency in oil palm plantation. Establish activities for determining high water use efficiency planting material using physiological approaches and data collection on physiological changes in oil palm.	MPIC/KASA	0.5	0.2	0.1	0.1	0.1	1	-	-	-	12th MP	Not a project under MP To increase oil palm yield.
			Study on enhancement of oil palm water use efficiency in water deficit condition.	MPIC/KASA	0.05	0.05	0.05	0.05	0.05	0.25	-	-	-	13th MP	Not a project under MP. To increase oil palm yield.
			Organise a workshop to introduce new technology packages to pepper growers.	MPIC/KASA	-	-	-	-	-	-	0.1	0.1	0.1	12th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/agencies held on 8 June 2021

		Public health emergency preparedness, climate-disease surveillance and coordination of environmental health data.	Develop an integrated database system of epidemics and environmental disasters that include infectious disease notification system, e-BAS system (e- Environmental Disaster Data System) and Inter-Agency Emergency Operation Centre Network (i-NET) (Centre for Disease Control) e.g. Food technology to increase productivity and adaptability to climate (university research).	MOH/KASA/ NADMA	-	-	-	-	-	1	-	-	-	12th MP	Integration of DRR & CCA
			Strengthen (review) preparedness and response to extreme weather event (flood, heat wave, haze).	MOH/KASA/ NADMA	-	-	-	-	-	-	-	-	-	12th MP	Integration of DRR & CCA Use existing operational budget
			Surveillance system and early warning system; identify and prioritise new emerging pollutants of water quality parameters.	MOH/KASA	-	-	0.2	0.2	0.2	0.6	1	1	1	12th MP and beyond	Including sanitary survey which is an element of the existing drinking water quality programme (KMAM) and is useful for identifying new emerging pollutants (see below for detailed explanations) Cooperation between KASA and MOH to identify new emerging pollutants such as Endocrine Disrupting Chemicals (EDC) and Antimicrobial Resistance (AMR). Institute of Medical Research (IMR) with Engineering Services Division, MOH are also currently conducting a research on AMR in water supply system in Malaysia.
			Develop Drinking Water Quality Index (DWQI) using GIS through the cooperation with MYSA.	MOH/KASA	-	-	0.2	-	-	0.2	-	-	-	12th MP and beyond	Pilot projects in Selangor and Negeri Sembilan have been completed., and to be extended to all states in phases starting 2022.

			Develop environmental health information system for coordinating health data.	MOH/KASA	-	-	5	5	5	15	-	-	-	12th MP	System is in the planning stage. Data sharing with built in security -Links all data in one database system e.g. water and health Linking climate change-environmental determinants-human exposure- effects requires big data, long term data and complex analysis (disease modelling & predictive analytics) Raw and drinking water, temperature and climate variables to identify high risk areas and population (pelan perancangan bandar tempatan/local township planning).
			Develop climate-sensitive disease surveillance system; to integrate climate data with relevant diseases.	MOH/KASA	-	-	-	-	-	-	2	-	-	13th MP	No integration of climate data in disease surveillance system
			Conduct vulnerability assessment of climate sensitive diseases.	MOH/KASA	-	0.2	0.2	0.2	0.1	0.7	0.7	0.7	0.7	12th MP and beyond	
			Conduct impact assessment of climate sensitive diseases (Disease burden and disease projection study).	MOH/KASA	-	-	-	-	0.3	0.3	0.3	0.3	0.3	12th MP and beyond	
			Provide a training in disease surveillance, registry and admission data for data analysis and management, health risk assessment and field simulation (interagency data & information sharing); develop GIS real-time monitoring and health-based warning system.	MOH/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	12th MP and beyond	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.
	Assimilating Knowledge to Improve Planning and Implementation	Vulnerability, hazards and emerging issues to address the impact of climate change and disasters.	Vulnerability and adaptation assessment (VNA) and emerging issue on climate and water-related diseases.	MOH/KASA	-	-	1	2	2	5	5	10	10	12th MP and beyond	

	Vulnerability, Impact and Integration of Climate Change Adaptation and Disaster Risk Reduction; risk assessment of water-related disasters and geohazards.	MOH/KASA	-	-	-	-	1.50	1.50	1.50	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.
	Develop a long-term physical oceanographic monitoring station across 14 Malaysia territorial waters to understand climate change impacts (sea level rise) in Malaysia.	KASA/ NADMA	-	-	-	-	6.00	3.00	1.50	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.
	Reconciliate among the dominance forces known as Silent Threats e.g SLR, Active Zone for erosion and accretion, storm surges and land subsidence as among the niche / crucial fields to be studied and research.	KASA/ NADMA	-	-	-	-	3.00	4.50	2.50	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.

			Address coastal and marine related disasters (e.g tsunami, coastal sediment transport (erosion & accretion) and develop guidelines for mitigation and adaptation plans.	KASA/ NADMA	-	-	-	-	-	-	2.20	3.00	3.00	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.
			Conduct research on identification of sensitive and high vulnerability areas to the impact of climate change and natural disaster, as well as the study of disaster risk reduction frameworks.	KASA/ NADMA	-	-	-	-	-	-	3.50	4.00	4.00	13th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.
			Conduct research and integration of climate change data and information in planning and risk reduction actions related to water disasters through the development/improvement of guidelines, procedures and other relevant technical documents.	KASA/ NADMA	-	-	-	-	-	-	2.30	3.00	3.00	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.

	Conduct research on capacity building programme and nature-based adaptation technology.	KASA/ NADMA	-	-	-	-	-	2.20	3.00	3.00	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. NAHRIM intends to establish the Climate Change Research Centre as a focal point in this field, including developing a group of national hydroclimate experts (SMEs).
	Strengthen capacity and mechanism in risk assessment and implementation on water-related disasters and geohazard: i. consolidating and identifying silent threats to coastal ecosystem e.g. SLR, coastal active zone (erosion & accretion coastal segment; storm surges prone area; land subsidence along the coastal area.	KASA/ NADMA	-	-	-	-	-	1.50	1.50	1.50	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.
	Develop a long-term physical oceanographic monitoring station across 14 Malaysia territorial waters to understand climate change impacts and collation of primary data acquired for hydrodynamic modelling works in Malaysia.	KASA/ NADMA	-	-	-	-	-	6.00	3.00	1.50	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Output from this research will be useful for NADMA, KASA and all relevant stakeholders related to hydroclimate hazard.

			Amplify and promote green infrastructure strategies towards impacts of climate change & sea level rise in Malaysia nationwide.	KASA/ NADMA	-	-	-	-	-	-	1.50	1.00	0.50	12th MP and beyond	Integration of DRR & CCA This scope has been dropped by EPU in the 12th MP and will be continued in the next 13th MP onwards. However, for the time being NAHRIM will use available internal allocations or funds from external grants applied for this research purpose from time to time. Safeguarding Malaysia coast from the impact of natural disaster and climate change impacts.
			Conduct research on improving resilience, vulnerability assessment, impact and adaptation of climate change on water resources and services.	KASA/ NADMA	-	0.5	1.5	1.5	0.5	4	5	5	5	12th MP and beyond	Integration of DRR & CCA Preliminary work for the updating of the NAHRIM RegHCM model based on IPCC AR6 will begin in 2022. IPCC Assessment Report will be revised for every 5 to 7 years. Expected revised year of IPCC Assessment Report: AR7 (2028), AR8 (2034) & AR9 (2040).
			Conduct research on identification of sensitive and high vulnerability areas to the impact of climate change and natural disaster, as well as the study of disaster risk reduction frameworks.	KASA/ NADMA	0.3	0.3	0.4	0.3	0.3	1.6	2	2	2	12th MP and beyond	Integration of DRR & CCA All the systems will be improved, revised and updated based on the updating data from AR5 (RCP Scenarios) NAHRIM RegHCM for the 12th MP. All the systems will be improved, revised and updated from time to time in line with revised versions and inputs of IPCC Assessment Report.

			Conduct research on Coastal Reservoir as a new freshwater resource for the city / state with higher population and water-demand for various purposes e.g. industries, irrigation and agricultural needs.	KASA/ NADMA	-	-	-	-	-	-	-	-	-	12th MP and beyond	Integration of DRR & CCA Successful track record in several densely populated and urbanised country e.g. China and India. Fresh Water Resources / option will strengthen KASA role in Water Scarcity issue / Gaps / solution in Malaysia.
			Conduct research and integrating of climate change data and information in planning and risk reduction actions related to water disasters through the development/improvement of guidelines, procedures and other relevant technical documents.	KASA/ NADMA	0.7	0.7	1.1	1.2	0.7	4.4	5	5	5	12th MP and beyond	Integration of DRR & CCA Output from this research activities will be used or adopted for incoming NC4 assessment (V&A chapter) National Communication (NC) must be updated for every 4 years and submitted to UNFCCC by KASA as fa ocal point.
			Mainstream sea level rise and storm surge projections into the Integrated Shoreline Management Plan (ISMP) and for the planning of coastal protection and development projects.	KASA/ NADMA	2	3	4	3.5	1.5	14	8	5	3	12th MP and beyond	Integration of DRR & CCA Budget approved in 12th MP under Sea Level Rise, Storm Surges and Coastal Geomorphology fund from EPU IPCC Assessment Report will be revised for every 5 to 7 years. Expected revised year of IPCC Assessment Report: AR7 (2028), AR8 (2034) & AR9 (2040). Malaysia utilises the Coastal Vulnerability Index (CVI) associated with SLR, as an essential indicator to evaluate the vulnerability and risk levels of shoreline. This will be embedded in mapping out vulnerability assessment of different socioeconomic segments. Efforts will be focused on intensification of developing coastline SLR-based inundation maps.

			Increase diversification and exploration of alternative water sources such as urban scale rainwater harvesting system, groundwater, recycled and reclaimed water for conjunctive use; and prioritise water demand management to reduce stress on water supply is high on the agenda.	KASA/ NADMA	2	-	-	-	-	2	3	1.5	2	12th MP and beyond	Integration of DRR & CCA Currently under proposal to be tabled to KASA Fresh Water Resources / option will strengthen KASA role in Water Scarcity issue / Gaps / solution in Malaysia
			Establish Malaysia Grand Challenge (MGC); offer five (5) R&D Funding Schemes.	MOSTI/KASA	80	100	138	130.3	51.7	500	-	-	-	12th MP	subject to the budget approval under MP. These schemes encompass the 10-10 Malaysia Science, Technology, Innovation & Economy (MySTIE) Framework by the Academy of Sciences Malaysia (ASM). The socio-economic drivers are inclusive of Energy, Water & Food, Medical & Healthcare, Agriculture & Forestry and Environment & Biodiversity.
		Strategic and emerging issues across terrestrial margins and oceans.	Capture the impacts of environmental change on primary production in the South China Sea from space; variabilities and precursor features of extreme rainfall events over Malaysia and its neighbouring sea in the changing climate; impact of climate change towards seaweeds.	MOHE/MAFI/ KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	12th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.
			Strengthen impact assessment research in line with climate change adaptation through the research on new fish breeds/traits; enhance culture and nursery systems; fish health and emerging diseases; aquaculture - environmental issues; strengthen data collection; proper spatial planning (including GIS), early warning systems and data sharing for aquaculture; species inventory; risk assessment of alien species; limnology and water quality; sanctuary establishment; public restocking; early warning system; proper spatial planning (including GIS); strengthen data	MAFI/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA.

			collection and data sharing for inland fisheries; fish stock assessment; fish biology study; establishment of new Marine Protected Area; development of artificial reefs; oceanography and marine science; early warning system; resource friendly gear; strengthen data collection; data sharing and spatial planning and forecasting (RS/GIS) in capture fisheries.												
			Practice a monthly site visit to the port operating area to improve water quality and reduce the Port's water usage.	MOT/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	Continuous implementation	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Kuantan Port Authority (KPA) & Port Klang Authority (PKA)
Finance	**Investing in Disaster Risk Management**	Disaster risk financing and social protection.	Conduct feasibility study, quantification of socio-economic impacts of disaster; develop policies on disaster risk transfer mechanism and establish alternative funds for disaster relief and recovery.	NADMA	-	0.75	0.75	0.75	0.75	3	-	-	-	12th MP	Consolidating financial protection.
		Mainstreaming disaster risk management in public investment.	Provide a development grant for cities to showcase best planning practices in climate-resilient efforts, IWRM, IRBM, ESA and climate change mitigation/adaptation and disaster risk reduction in land use planning. Conduct programme to recognise individuals, communities, institutions and Local Authorities which implement green neighbourhood initiatives such as urban farming, rainwater harvesting, composting and provision of pedestrian walkway. E.g.: Program Anugerah Kejiranan Hijau (AKH)	NADMA	-	-	0.5	5.5	5.5	11.5	27.5	30	30	12th MP and beyond Continuous implementation	i. Competition will be held to shortlist local authorities/cities with best planning practices in implementing IWRM, climate change mitigation/adaptation and disaster risk reduction in land use planning. This programme is open to all states in Malaysia. ii. Provide small development grants for selected local authorities/ cities based on the result of the competition to upscale the implementation of IWRM, IRBM, ESAs, climate change mitigation/ adaptation and disaster risk reduction in land use planning. iii. Replication of the best planning practices to other cities through knowledge sharing and seminar.

			Provide research grants for universities on planning for climate-resilient cities and hinterlands, IWRM, IRBM, ESAs, climate change adaptation, co-benefits and disaster risk reduction.	NADMA/ KASA	-	-	0.6	0.6	0.6	1.8	2	2	3	12th MP and beyond Continuous implementation	Research grant for local and foreign universities with research output in methodology, modelling and decision-making tools. Joint colloquium as a knowledge-sharing platform between universities, public institutions and industrial players. Compilation of research findings IWRM, IRBM, ESAs, Climate Change Mitigation, Adaptation, Disaster Risk Reduction and Landuse Planning. i. 10 research grant/year = RM500,000 ii. 1 joint colloquium/year = RM30,000 iii. 1 compilation of research findings = RM30,000 iv. research activities (data collections, TNT etc) = RM40,000
			Irrigation system and crop production technology for rural stakeholders: Subsidise irrigation system and white pepper production technology to rural stakeholders.	MPIC/KASA	-	-	-	-	-	-	1	1	1	13th MP and beyond	Consolidating financial protection.
	Strengthening Financial Capacity for Climate Resilience	Climate resilient and environment-friendly financing and alternative sources of income.	Conduct feasibility study for adaptation and resilience; scale-up climate resilient and environment-friendly financing and investment from the private sector, CSOs and individuals.	KASA	-	0.75	0.75	0.75	0.75	3	-	-	-	12th MP	

			Review the health financing mechanism.	MOH/MOF	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	12th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. (GDP 4.75%, 53% to MOH, the rest are insurance, out of pocket, health facilities, military health, etc.) Report MOH 2018 Source - tax Report ASM 2000 Needs to double amount of resources for health =9%/ social health insurance/ MySalam to B40 Indonesia e.g. Political will--freedom of speech--reform--decentralisation--all provincial governments have responsibilities Paper Lancet 2013 financial reform 1. Lack of technical capacity to run health financing system. 2. Lack of political will. 3. Influenced by private health insurance companies who lobby against social health insurance. Social health insurance unites public and private healthcare system OECD report on climate change. Service providers, policy makers, enforcement, research, training let universities do research, leaving only 1 research centre; IMR
			Provide insurance and disaster fund for fishers and farmers; financial loan with flexible repayment; development fund for fisheries department for all CCA programmes and operating fund for CCA programmes.	EPU/MOF/ MAFI/KASA/ NADMA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Integration of DRR & CCA

Infrastructure & Technology	**Enhancing Early Warning Systems and Disaster Response**	Framework for subsurface geological hazards and early warning for better preparedness of at-risk communities.	Subsurface geological systems: Develop DRM plan including regulations, early warning, monitoring and understanding of subsurface natural hazards through establishment of a database and geological models (2D,3D and 4D) in Greater Kuala Lumpur as a pilot.	NADMA/ KeTSA	-	2.5	2.5	2.5	2.5	10	15	20	30	12MP and beyond	Disaster risk management (DRM) initiatives for unforeseen subsurface geological hazard and risk. Type of monitoring such as; i. Datum point and bench marker ii. Environmental geochemistry iii. Subsurface movement (e.g tilt meter etc.) iv. Ground (stress and strain) stress magnitude and direction monitoring. v. Temperature, conductivity of ground water (dissolved mineral, level etc.) insitu borehole monitoring. Subsurface geology model and inventory; Subsurface DRM Plan and Early Warning System; and Regulations for Subsurface Development for Greater Kuala Lumpur. 13 MP, 14MP & 15MP will cover urban area of whole Selangor state.
			Subsurface geological systems: Develop DRM plan including regulations, early warnings, monitoring and the understanding of subsurface natural hazards through establishment of a database and geological models (2D,3D and 4D) for Ipoh, Johor Bahru, Penang, Kuching, Kota Kinabalu and all other states capital that include existing and expanding urbanised areas.	NADMA/ KeTSA	-	-	-	-	-	20	15	50	50	12MP and beyond	Disaster risk management (DRM) initiatives for unforeseen subsurface geological hazard and risk. Type of monitoring such as; i. Datum point and bench marker ii. Environmental geochemistry iii. Subsurface movement iv. Ground (stress and strain) stress magnitude and direction monitoring. v. Temperature, conductivity of ground water (dissolved mineral, level etc.) insitu borehole monitoring. Subsurface geology model and inventory; Subsurface DRM Plan, Early Warning

															System, and Regulations for Subsurface Development for Ipoh, Johor Bahru, Penang, Kuching, Kota Kinabalu and all other states capital that include existing and expanding urbanised areas.
		Land use scenario planning model and decision-support system for development control.	Develop a land use scenario planning model for 13 local authorities, linking to their GIS system for better decision-support in planning and development control, integrating IWRM, IRBM, ESAs, Climate Change Mitigation, Adaptation, Disaster Risk Reduction and Land Use Planning.	NADMA	-	-	-	-	-	-	-	7	7	15th MP	Develop land use scenario planning model (based on climate change impact eg.1.5°C rise) and develop decision support system integrating IWRM, IRBM, ESAs, Climate Change Mitigation, Adaptation, Disaster Risk Reduction and Landuse Planning for 14 local authorities. (1 local authority from each state in Malaysia including Kuala Lumpur). i. 1 million for each local authority. ii. 7 local authorities for 14 MP (7 millions). iii. 7 local authorities for 15 MP (7 millions).
	Developing Sustainable Infrastructure with Cost Effective Technology	Infrastructure and technology for flood and coastal protection.	Incorporate climate change factors (CCF) at river basin level into flood mitigation design to minimise the flood impacts and include sea level rise factors in coastal protection structure design.	KASA/ NADMA	2	2	2	2	2	10	10	10	10	12th MP and beyond	Integration of DRR & CCA Currently JPS use CCF according to region in Malaysia. New Study by JPS-NAHRIM need to be conducted for safety and economical design to adapt the climate change impact in the future at river basin level.
			Develop and enhance existing infrastructures for NAWABS and NaFFWS with current and future technology related to climate change impact.	KASA/ KeTSA/MAFI/ NADMA	40	40	40	40	40	200	100	100	100	12th MP and beyond	Integration of DRR & CCA Tubewell, Telemetry Stations, ICT Hardware and other infrastructures

			Flood barrier door system: Conduct preliminary study, product development, product testing, patenting and promotion for the innovation in flood door used for housing areas.	KASA/ NADMA	-	1	1	1	1	4	-	-	-	12th MP and beyond	Integration of DRR & CCA The flood door will be installed at housing area that affected by flash flood.
			Remote sensing and related technologies: Identify shoreline changes and its impact to mangrove forest using Geospatial Techniques; and identify areas at high risk of coastal erosion as well as making projections of changes to the country's coastline.	MOSTI/ KASA/ KeTSA/ NADMA	-	90	50	70	-	210	-	-	-	12th MP	Integration of DRR & CCA Shoreline is generated from satellite imagery, while shoreline changes, rate of change and change projection are analyse using geospatial technique. Shoreline changes at Tanjung Burung Forest Reserve, Perak over 32 years using geospatial technique.
		Health, water, food and energy nexus at the river basin level.	Safe drinking water supply: Improve low cost technology approach and upgrade water treatment system for alternative rural water supply.	KASA/MOH	-	22.11	22.11	22.11	22.11	88.44	110.53	110.53	110.53	12th MP and beyond	Upgrade all the alternative water supplies for rural areas with appropriate technology. Project under MOH Coverage only. Coverage for Safe Water Supply for Rural Area - 96.84%.
			Environmentally sustainable health care facilities: Develop green hospitals and green healthcare initiatives through the use of rainwater harvesting system, integrated water management system, water efficient fittings and etc.	MOH/KASA	-	-	-	-	-	1	-	-	-	12th MP	
		IoT for agriculture and forest sectors to build climate resilience.	Water management for agriculture; Develop fertigation system equipped with soil sensor and IoT system for cocoa adaptation during extreme climate changes and optimise water usage in cocoa plants through IoT management.	MPIC/KASA	-	-	-	-	-	0.5	-	-	-	12th MP	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021.
			Develop auto-control system of micro-irrigation in the cocoa nursery for optimum water usage purpose.	MPIC/KASA	-	-	-	-	-	-	1	-	-	13th MP	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/ agencies held on 8 June 2021.

			Develop a water recycling system for kenaf bio-retting processing (under Program Kenaf Untuk Rakyat Secara Berkelompok bagi Pengeluaran Fiber Premium).	MPIC/KASA	-	1.25	1.25	1.25	1.25	5	6	-	-	12th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/agencies on held 8 June 2021.
			Develop a water recycling system for kenaf pulp and paper processing (under Program Tanaman Baharu Kenaf).	MPIC/KASA	-	1	1	1	1	4	-	-	-	12th MP	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/agencies held on 8 June 2021.
			Develop wastewater treatment system for Malaysia Pepper Board Sibu and Sarikei, Sarawak.	MPIC/KASA	0.15	3.86	2.20	0.79	-	7	-	-	-	12th MP	IECS to obtain the current level of effluent at both centres. The project has also already been awarded to successful tenderer This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/agencies held on 8 June 2021
			Peat and oil palm plantations: Conduct survey of peatland hydrology for specific study site in Sarawak, develop different water table in study site with replanting oil palm for monitoring of oil palm growth and productivity, replant the area with suitable clonal oil palm for deeper water table and monitor carbon balance and oil palm performance.	MPIC/KASA	0.5	3	2	1	1	7.5	-	-	-	12th MP	
			Implement new water management technology (IoT integrated irrigation system) on pepper farming among farmers.	MPIC/KASA	-	-	-	-	-	-	1	-	-	13th MP	(Currently there is no standard irrigation system for pepper as most of pepper growers in Malaysia rely entirely on rainwater) This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/agencies held on 8 June 2021.

			Implement new post-harvest technology (IoT application) on white pepper production among farmers.	MPIC/KASA	-	-	-	-	-	-	0.2	0.2	0.2	13th MP and beyond	This proposed programme/initiative has been submitted to ASM after the WST2040 Roadmap consultation session between ASM and all relevant ministries/agencies held on 8 June 2021.
			Reduce Emissions from Deforestation and Forest Degradation (REDD Plus); Upgrade high-tech workstation towards the implementation of AI technology.	MOSTI/KASA	-	-	250	-	-	250	-	-	-	12th MP	Current workstation almost reaching maximum capacity
			Develop early warning systems to fisheries and aquaculture; relocate farms/cage from flood/drought prone areas and invest in indoor aquaculture system.	MAFI/KASA/ NADMA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	13th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Integration of DRR & CCA
			Use high resolution remote sensing data and Artificial Intelligence (AI) Technology for automated mapping of forest cover change; use Near Real Time forested area monitoring and change detection; use of hyperspectral data to support more detailed information needs; develop fully online data entry and processing; enhance collaboration with local experts (Research University) related to the latest technology.	MOSTI/ KeTSA/ MOHE /KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	12th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Forest cover mapping periodically every two years; In-House development of web-based Geographic Information System (GIS) application that comprises of geospatial and remote sensing information of forested area.
		Risk reduction and adaption for strategic infrastructure.	Establish an emergency flood mitigation system at airports (Kuala Terengganu Airport, Kota Bharu Airport, Alor Setar Airport, Kuantan Airport, Kota Kinabalu Int. Airport, Ipoh Airport); complete water treatment plant for alternative water supply at KLIA and supply treated water from Southern Balancing Pond (SBP); use recycle natural rain water for irrigation purposes in Penang Int. Airport, Kota Kinabalu Int. Airport, Kuching Int. Airport, Langkawi Int. Airport, Kota Bharu Airport, Kuala Terengganu Airport and Miri Airport.	MOT/KASA/ NADMA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	12th MP	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Integration of DRR & CCA Planning/ System Study; collaboration with Business Partner

			Conserve energy and maximize energy efficiency of Port operations; reduce waste from port operations through material reuse, recycling and composting; promote economic, social and cultural progress through an environmentally sound and sustainable development within port area.	MOT/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	Continuous implementation	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Port Klang Authority (PKA)
			Use more energy efficient and environmentally friendly equipment (VRF system and R-32 cooling on all air conditioners); collect rainwater for daily operational use such as cargo watering, bay washing and dock washing and retreat water throughout the port area to reuse for post-port operations purposes; use LED/CFL lights throughout the port area in stages as well as explore and implement other appropriate energy efficiency initiatives; use hybrid RTG and on-shore power supply for long-term plan.	MOT/KASA	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	Continuous implementation	Budget not given (N/G). The proposal will be reviewed by KASA and NADMA. Kuantan Port Authority (KPA)
	Enhancing Disaster Preparedness and Recovery	Resilient construction guidelines and standards for retrofitting and reconstruction of damaged buildings and infrastructure.	Develop a design code related to earthquake resilient infrastructure, resistance and retrofitting of building.	NADMA	0.15	0.2	-	-	-	0.35	-	-	-	12th MP and beyond	a. MS EN 1998-1, Design of Structure for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings and its National Annex (Completed); b. MS EN 1998-2, Design of Structure for earthquake resistance - Part 2 : Bridges (in-progress, target completion date : Q2 2023) c. MS EN 1998-3, Design of Structure for earthquake resistance - Part 3: Assessment and retrofitting of buildings d. MS EN 1998-4, Design of Structure for earthquake resistance - Part 4: Silos, tanks and pipelines e. MS EN 1998-5, Design of Structure for earthquake resistance - Part 5: Foundations, retaining structures and geotechnical aspects f. MS EN 1998-6, Design of Structure for earthquake resistance - Part 6: Towers, masts and chimneys